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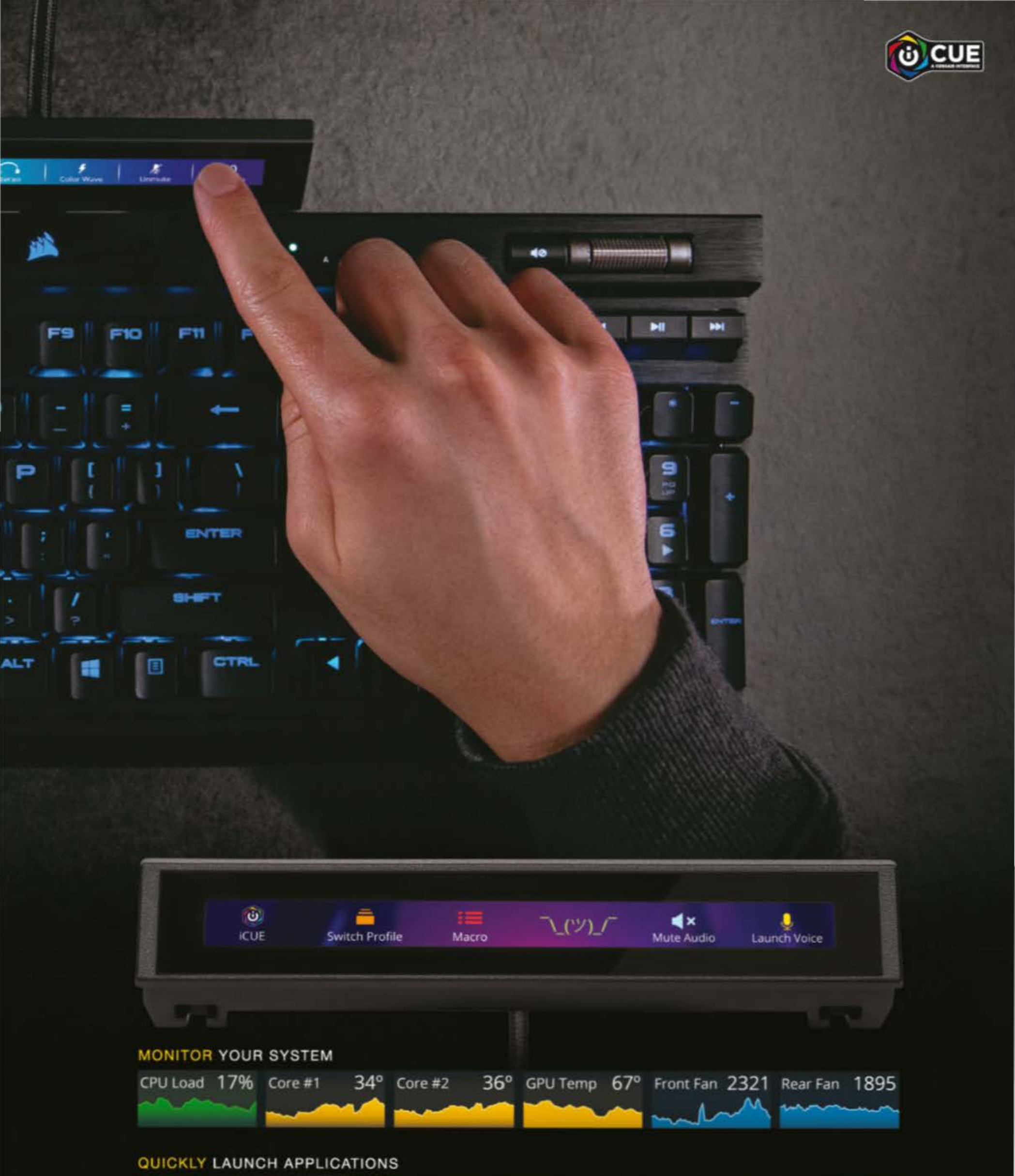

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Zak Storey

VIDEOGRAPHY MASTERY

ALTHOUGH Moore's Law may be fluttering around the edges today, its effect on the industry is well-documented, and very apparent. In fact, thinking of computing performance, just how much we've managed to gain in ever-smaller form factors is seriously impressive. Take Apollo 11's guidance computer, for example: According to some figures, modern iPhones house over 100,000 times more processing power than the legendary computer that landed man on the Moon. And that's just in the world of mobile....

Even in the last five years in our own heady domain, computational performance has quadrupled in the mainstream marketplace, and in the land of HEDT it's more than six times higher than when we first started, and that's just on core count alone. Moore's Law may not be to thank for that—intuitive complex chip design is—but nonetheless the amount of power we can achieve in our mid towers today is incredible. And that got us thinking.

Just what can you do in the smallest of form factors. In particular, we're talking about ITX. It's long been a love of mine, for gaming or otherwise: The perfect balance between size and performance. In fact my very first rig that got me into *Maximum PC* to begin with was a conversion of an ATX tower into the BitFenix Prodigy ITX chassis with a Core i5-2500K at its heart. It was only when I managed to overclock that processor all the way up to 5.4GHz on a single 120mm radiator that I began to understand just what you could do with the form factor. It was small, compact, easy to transport, and yet insanely powerful, and a match for some of my friends' biggest machines.

Fast forward to 2020, and that i5-2500K's heyday is long over, so I set Christian to the task of building a super-small form factor PC, designed specifically with video-editing in mind. ITX comes with limitations: Two slots for memory, very few storage options, and a single add-in card, so just how well would it do, and what's the most we could put into it? You might be surprised how much we managed to get out of that beautifully crafted NZXT H1 chassis.

This issue we've also recruited Gavin Bonshor of *Anandtech* fame to break down exactly what makes motherboards tick on PG 34. On top of that, we've decided to overhaul our benchmarking suite and testing methodologies, and introduce a digital benchmark database that you can check out on PG 28.

But it's not all just videography and charts. In our build-it this issue, on PG 56, we've decided to take on AMD's Ryzen 3 3300X to see how well it performs at 1080p and 1440p gaming. This quad-core, eight-thread processor is in high demand, and with good reason: Coming in at just $127, it's the equivalent of a modern Core i7 from 2017 and makes mince meat out of any AAA title you throw its way.

On top of all of that, we've got a selection of fantastic how-to tutorials, including how to test your SSD, a continuation of our WordPress tutorial series, detailing how to create posts and pages, and a bevy of reviews, columns, and more.

Stay safe out there, and I look forward to seeing you next time.

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

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What the future holds for your next PC processor PG. 38

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THE NEWS

Threadripper Goes Pro

The most powerful workstation chip ever

AFTER WEEKS of rumors and leaks about AMD's new Threadripper, AMD has revealed what it likes to call "the first and only 64-core professional workstation processor": the Threadripper PRO 3000WX series. There are four in all. The top model is the Threadripper PRO 3995WX, which has 64 cores and a base clock of 2.7GHz, with a maximum boost to 4.3GHz. Below this are the 32-core 3975WX, the 16-core 3955WX, and lastly the 12-core 3945WX. The clock speeds increase as the core count drops, all the way up to 4.0GHz on the base model 12-core chip. Essentially they are pro versions of existing Threadripper chips, employing the same 7nm Zen 2 cores: The 3995WX is a 3990X, and so forth. The base clock rates are a shade lower across the range, probably down to extra overheads running the memory—the 3995WX loses 200MHz to the 3990X. The PRO range is overclock locked, unlike its predecessor, which is a clear sign of the difference in intended markets.

The main changes take place around the processor's core, and chief of these is the memory controller, which now boasts eight channels of DDR4-3200 memory rather than four. Memory bandwidth can be a problem on the 3990X, particularly if you want to hit all those cores effectively. The PRO has effectively doubled the bandwidth at a stroke. The maximum memory size is 2TB across the range, which is an awful lot to put into one box. You also get more PCIe 4.0 channels, up from 88 to 128. AMD claims this is a first for this market: Although the Threadripper already has PCIe 4.0, it's not considered a "professional" chip. There's also a dedicated security chip and Memory Guard, which offers full memory encryption, so sensitive work that's stolen or lost is safe. The TDP rating hasn't changed from 280W. This is generated by an odd AMD-only calculation that has little to do with power draw at all—in fact it isn't factored into the calculation.

The promotional material contains the usual bar charts showing a performance lead over Intel chips—it's hardly an independent source, but telling nevertheless.

> The top model is the Threadripper PRO 3995WX, which has 64 cores.

AMD says this is the "ultimate processor for the workstation"—and might be right.

The 3995WX out-guns the Intel Xeon W-3275 and dual Xeon Platinum 8280s when running benchmarks using dozens of industry-standard heavyweight applications involving video work, mathematical modeling and so forth, typically by a margin of around 20 percent. Anything that can use that extra memory bandwidth shows a big jump.

Along with new chips, we have a new platform, designated WRX. This uses a sWRX8 socket, required because of the new pin-out map required by those extra memory channels. The "W" is for workstation, the "8" for eight-channel memory, and the "X" doesn't stand for anything but looks good. The accompanying chipset is the new WRX80. We have little on this as yet. Acer and Gigabyte are working on boards.

We have no prices for individual chips yet either. Initially Threadripper PROs will only be available inside prebuilt systems. If you want an individual chip you are invited to contact AMD for a quote, but don't hold your breath. The first Threadripper PRO system is from AMD partners Lenovo: The ThinkStation P620. It's a bit of a monster, with up to four Nvidia Quadro graphics cards. It's offered as a powerful alternative to multiple processor systems (i.e. Intel ones). Each is built to order, and prices start from $4,599 and go considerably higher than that. All this is packed into a modest-sized box. The P620 should be available this fall.

Thhreadripper sits between the desktop Ryzen, and the server-only EPYC. While not designed to sit in a server rack, it is quite a beast for a desktop. The Threadripper PRO further defines that split. The Threadripper is for the high-end desktop, and enthusiasts. The new Threadripper is pitched directly at professional creatives using workstations.

The distinction between Threadripper and EPYC is that it's still a single-socket chip: You can't build multiple processor boxes or mount them in racks. It does mean you can use fairly standard cases, and ancillary components.

Why are we interested in the Threadripper PRO? Because what's in a workstation one year is in a desktop later–it will trickle down the chain. And it's so powerful, even if it's not really meant for us, we still want one. **–CL**

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OCULUS GO GONE

Low-cost headset is to be dropped

OCULUS HAS two versions of its standalone VR headsets: The accomplished Quest, and the considerably cheaper Oculus Go. But no longer, as the Oculus Go is to go. There will be no new software or updates after December, although you'll still receive security patches and bug fixes until the end of 2022. The Go was an attempt at low-cost VR. Lacking position tracking and fancy controllers, it managed to sell over 2 million headsets in a year. The Go was designed to introduce VR to people unwilling to invest in the bigger headsets, but the limited capabilities didn't show VR at its best, and it was still too expensive for the mass market. Oculus is to concentrate on higher-end headsets with the full six degrees of freedom, and high-resolution graphics.

Oculus claims its customers have spent over $100 million on the Quest, and that more than 10 games have broken through the $2 million barrier. **–CL**

SECOND NEW XBOX DUE

CHEAPER SERIES X FOR 1440P

THERE HAVE BEEN MUTTERINGS of two versions of the Xbox Series X for months. We had two codenames after all: Anaconda, and Lockhart. Leaked documents confirm that Microsoft is going to make another more affordable version of the X Series. It will be aimed at 1080p or 1440p gaming, rather than the exotic heights of 4K and beyond, which will keep the cost of the required graphics silicon down. It makes sense: The company sold two version of its Xbox One after all. It also enables Microsoft to undercut the PS5 with a "budget" model, and out-perform it with the full version. Tech specs are unsubstantiated, but it is expected to run a slightly slower CPU, have less usable RAM and a slower GPU, and ship with no optical drive. The end result is a box with less power than an Xbox One X but able to play the latest X Series games. We don't have a name or price yet, but S Series and $399 are widely touted. We expect a launch announcement soon, with the boxes arriving in time for the holidays. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

NEW CHAMPION
Fujitsu has unveiled its Fugaku supercomputer, with 158,976 ARM A64FX processors.

NO DOUBLE-DIPPING
Microsoft's Smart Delivery system for Xbox games won't allow developers to charge you for a Series X version if you already own the game.

THUNDERBOLT IS STILL GO
Intel has release the specs of Thunderbolt 4, due to debut with its Tiger Lake chips.

TRAGEDIES

END OF SEGWAY
After 18 years the iconic Segway PT is to retire. The company is to concentrate on electric scooters.

BLU-RAY FAIL
Thousands of Samsung Blu-ray players have died at once, perhaps due to a firmware problem with expired SSL certificates.

PAY TO PLAY
Google Play Music is to close as YouTube Music takes over. There's a fee to use Google speakers, even if you own the music.

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APPLE'S TRANSITION

Two-year plan unveiled

APPLE'S DECISION to ditch x86 processors and move to ARM-based chips for all its machines has caused a stir. Now we are starting to get an idea of what's in store as development kit is distributed, based around the existing A12Z Bionic chip, along with beta software. There are no meaningful direct benchmarks yet, its not the final hardware, or software, and there's lots of emulation going on. However, developers have been impressed. Apple's new iPad Pro already runs an A12Z chip, and it's no slouch, holding its own against a MacBook Pro armed with a Core i5-8257. The next version will be based around this, although exact details are still fuzzy. We can expect a SoC version with more cores, higher frequencies, and integrated GPU. Some analysts are predicting performance hikes of between 50 and 100 percent when ARM MacBooks land.

While Apple gave little away about the silicon at the World Wide Developers Conference, except that it was going to be "truly profound." It did want to talk about its software, and unveiled Universal 2. This is a classification for executable files that will run on x86 and ARM. The software detects what you have and proceeds accordingly. Many of the big productivity applications, Photoshop and the like, have already been ported. The original Apple Universal binary from 2005 did the same job during the transition from PowerPC chips to x86, and this is the third time Apple has switched tracks now. The plan is for the full transition to take two years, and will kick off with MacOS 11 (Big Sur), and the ARM-based 13-inch MacBook Pro and MacBook Air.

If Apple has waited this long to jump, we can assume it is confident. Intel and AMD have some thinking to do. The A-Series ARM chips have had a record of improvements. ARM chips are also gaining ground in supercomputers and server farms, as well as dominating mobile devices, leaving x86 silicon in the middle. **–CL**

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> CPU Overheating
> M.2 NVMe vs SATA
> HDMI Voltage Bleed

Unexplainable Data Loss

I have an HP Elitebook that is currently fitted with a 2.5-inch SSD as the main Windows 7 drive, and a 1TB mSATA that contains working files and a majority of VirtualBox images as both VHD and VDI files.

I have recently swapped out the 2.5" SSD with another one and installed Windows 10 on it, which has gone very smoothly apart from one issue: When I swap back to the Windows 7 SSD I notice that I have lost some VDI files completely, and others have been corrupted.

I have managed to recover some of the lost files from backups and have tried the swap again, and the same thing keeps happening.

What is causing this, and is there anything I can do to stop this? At some point, I will permanently swap the Windows 7 SSD out and use the Windows 10 one, but I'm concerned about data loss on my mSATA. Any help is most appreciated. **—Stuart Mackey**

THE DOCTOR RESPONDS: The Doc posits the theory that the dual-boot setup is the problem. If the problem only occurs after shutting down Windows 10, then it appears that the file-system on your data drive isn't being unmounted properly, resulting in file corruption. Have you run disk checks on the drive? If problems are found (and subsequently repaired) it would confirm that diagnosis.

If the diagnosis is confirmed, then there's one possible reason: Fast Boot. Windows 8.1 and 10 both utilize this to speed up startup by only performing a hybrid shutdown that combines classic shutdown mechanisms with hibernation. Try disabling Fast Boot in Windows 10 to see if this fixes the issue: Select "Additional power settings" under "Settings → Power & sleep." Click "Choose what the power buttons do," followed by "Change settings that are currently unavailable," then untick "Turn on fast start-up (recommended)" and click "Save changes."

If this doesn't fix the problem, then the Doc wonders if your mSATA drive configuration is to blame somehow. The port is designed for use as an optional flash cache to accelerate performance on non-SSD drives rather than out-and-out storage, so that may be a factor. Think about how you set the drive up initially—with Intel Rapid Storage maybe? If so, it will have set up a cache and then made the rest of the drive available as storage, so perhaps swapping Windows installations disrupts this process and leads to the file corruption you experience.

Again, a disk check should diagnose and clear the problem. It's also worth visiting the drive manufacturer's website to see if you can locate a drive utility that can be used to monitor the drive health and maybe even help reconfigure it if necessary. Ultimately, though, we recommend taking the time to migrate fully to Windows 10 now. Windows 7 is no longer secure, so if all else fails make the switch, and see how your PC behaves with Windows 10 as its only OS.

CPU Overheating

Hey Doc, long-time *MPC* reader and troublemaker here. I have a question about a CPU I'm trying to use, an older Intel 4600k I recently re-seated in an old chassis (ASUS H97, Corsair H100i GTX). I didn't bother reapplying thermal paste because it was still intact with the cooler. On firing it up, my CPU temps have doubled from a cool 30/40 C to 60/80 C. All six fans are flowing correctly: Three at the front, two on the radiator, and one on the exhaust chassis. However, my cooling pumps are off—one doesn't seem to be flowing at all, and the other is very hot. I can jiggle the suspect pump and the CPU immediately cools off but cannot correct the issue. Presumably, this rules out the thermal paste and points to a defective cooler? **—Ryan Pitts**

THE DOCTOR RESPONDS: All your symptoms clearly indicate that the cooling pump needs replacing—and the *MPC* team have a similar experience to back up that diagnosis too. That said, while the chip is running hotter than you'd like, 60-80 C is within its normal limits—ideally it'll stay under

This low-profile cooler is an excellent budget choice for Intel CPUs.

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↘ submit your questions to: doctor@maximumpc.com

75 C, but unless you plan to push this PC or use it regularly, you should be able to make do with the existing cooling.

Alternatively, look to either apply new thermal paste (a tube of MX-4 costs around $15) or replace your stock cooler with a budget, but effective, alternative like Noctua's NH-L9i low-profile cooler, which is around $40 on www.newegg.com. One reviewer reports having used it for five years on a gaming rig with poor ventilation without ever seeing temps peak above 65 C.

M.2 NVMe vs SATA

I have a Dell 5675 with a Ryzen 7 1800X and am not a gamer. The computer came with an M.2 boot drive—I want to swap it out for an NVMe one, and there is an empty slot. However, I can't seem to get the computer to recognize the NVMe drive. What am I doing wrong? Maybe the bigger question is: Will I see improved start-up times?

—Kurt Wagner

THE DOCTOR RESPONDS: The Dell community forums are littered with posts about swapping out the SATA M.2 drive supplied by Dell for a faster NVMe drive. One interesting observation is that the NVMe slot found on your Dell motherboard only supports Gen2 x4 speeds (around 1.5GB/s)—significantly faster than SATA (600MB/s), but half the NVMe maximum (3.2GB/s).

Some Dell users have reported success investing in an M.2 PCIe x4 adapter—plug this into the second graphics card slot and you'll be able to use the PCIe 3.0 bus to boost your speeds to their maximum. Other Dell 5675 users have reported success with a Mailiya model (currently $50 from www.newegg.com), but we suspect you'll get the same results with the much cheaper Rivo ($15 from www.amazon.com).

Once physically fitted, boot into Windows and the drive should be physically visible in Disk Management, ready for configuration.

NVMe on PCIe is significantly quicker than SATA.

It's worth visiting the drive manufacturer's webpages for any additional software—for example, Samsung Magician for Samsung drives can help you configure, update, and benchmark your new drive. Samsung also provides a data migration tool to clone your current drive to the new one.

Once cloned, you'll need to remove the original drive temporarily before powering back up, and Windows should now boot from the newer drive. Once you've successfully booted once, you can refit the older drive, which will be set to offline due to a signature collision with the newer drive. You can then convert your old drive into a data or backup drive by first wiping it from the command line—see https://bit.ly/MPCseagate for a guide—and then setting it up as normal.

As for performance, you're never going to get Chromebook-style boot times of under 10 seconds—even with a quick POST, you're looking at boot times of around 40 seconds to the desktop, plus however long your start-up apps take. But NVMe is significantly faster than SATA, particularly on the PCIe 3.0 bus ,and you'll definitely feel the benefit in terms of snappier performance and boot times.

InstallShield Error 628

I'm running Windows 10, 1909 (updated from Windows 7 a few years back). I was trying to install an older chess game from an older laptop, and I received an error message: "Error 1628: failed to complete installation." I've tried every remedy on the internet: Renamed the InstallShield folder, emptied the Temp directory. I've even tried ending the IDRIVER.EXE process via Task Manager, but nothing has worked. Can you help?

—Jerry Semler

THE DOCTOR RESPONDS: Ah, "good-old" InstallShield. The simplest thing to do here is write it off—InstallShield is old tech and a pain in the butt to troubleshoot, as the Doc has found to his cost over the years. Without knowing the exact game, the Doc can't tell you whether it runs in Windows 10 anyway, but one ancient chess game that utilizes InstallShield is *Chessmaster Grand Edition* from Ubisoft. A search of online forums reveals it will work on Windows 10 (after upgrading from Windows 7 at least), but there are compatibility issues.

This might be one of those occasions where exploring an alternative means of running the game may be in order—for example, using virtualization software like Microsoft's own Hyper-V platform (Windows 10 Professional required) or VirtualBox (www.virtualbox.org) in conjunction with a copy of Windows XP, Vista, or even 7.

Ultimately, though, if you rely on InstallShield for any programs still running, then now is the time to investigate a clean reinstall of Windows (particularly if you've not done so since upgrading from Windows 7). InstallShield gets so messed up that it's almost impossible to remove or fix. Then, going forward, get into the habit of taking regular drive image backups of your Windows installation using a tool like Macrium Reflect Free (www.macrium.com/reflectfree.aspx), so that when you run into a problem like this in future, resolving it involves rolling back your PC a few days or a week rather than having to reach for the nuclear option.

HDMI Voltage Bleed

I've seen videos on the internet showing arcing coming from coax, USB, and HDMI cables when they seem to get high voltage between the conductors and ground shells. What advice can you give to avoid burning up expensive equipment due to what seemed to be termed "voltage bleed over" from an offending device's HDMI socket?

—Steve Bigelow

THE DOCTOR RESPONDS: This feels like more of a question for an electrician, but it's basically caused by faulty electronic components that "bleed" out high amounts of voltage through your display's ports. The source may be the display itself, but it may also be caused by another device connected to your display—for example, a TV box.

Electricians use so-called Foreign Voltage detectors to confirm the diagnosis: First, wave this close to the surface of your TV, then hold it close to the tip of an HDMI cable that's only plugged into the TV. The issue can be fixed by installing a grounding module into your electrical outlet, then use coax wire to connect the coax screw on the back of your TV to the coax screw on the unit. Tii Technologies produces such modules—see its website at https://bit.ly/MPCtitech for more details.

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PART		STREET PRICE
Case	NZXT H1 Black	$350
Mobo	MSI MPG B550i Gaming Edge WiFi	$200
CPU	AMD Ryzen 9 3950X	$700
CPU Cooler	140mm NZXT H1 integrated AIO cooler	N/A
Memory	64GB (2x32GB) HyperX Predator DDR4 @ 3200MHz	$314
GPU	Nvidia GeForce RTX 2080 Super Founders Edition 8GB	$700
PSU	650W NZXT S650 integrated PSU	N/A
SSD	2TB Corsair Force MP600	$400
OS	Windows 10 Pro	$200
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COMPACT COMPUTING

Build yourself a desk-friendly videographer's machine

High-end videography work (whether that's live streaming, post-production editing, or something else entirely) often demands a powerful PC. 4K video editing, exporting, and encoding are all resource-intensive tasks, and trying to do them with a sub-par or ageing machine is sure to lead to lengthy processing times and general frustration.

Such powerhouse machines are also often pretty chunky. It's part of the reason that Apple's desktop products have become successful within the creative industry; the all-in-one form factor of Macs is a great space-saver, tucking a purpose-built compact machine away behind a large monitor. But for those who prefer PCs, a system that can comfortably handle demanding video tasks is often going to be large, heavy, and potentially quite loud.

Such machines either take up a significant amount of available desk space or need to be placed underneath the desk itself, making cabling and access a hassle as well as potentially worsening airflow, since the system is closer to the floor. Fortunately, your friendly neighborhood computer magazine is here to show you how to make a videography machine that has both a compact desktop footprint and a ton of powerhouse components.

Whether you would choose PC over Mac for software and OS reasons or just the superior customizability of PC hardware, there are a few benefits to consider here. Windows is obviously one of them; the world's most widely used operating system is ideal when it comes to compatibility and familiarity. We're deviating from the norm, though. You'll notice in our list of ingredients that we've opted for Windows 10 Pro, the more powerful version of Microsoft's flagship OS. It's also more expensive than Windows 10 Home, so if you don't need the Pro upgrade, consider it merely a suggestion.

Pro's main benefits are improved security (with BitLocker encryption) and a suite of various enterprise features; it's up to you to decide whether you actually need that in your professional capacity. This isn't a cheap system, so if you want to save some cash you can buy Home.

Now, without further ado, let's take a look at the physical parts we're using to build this system. –CHRISTIAN GUYTON

MOTHERBOARD

MSI MPG B550i Gaming Edge WiFi
$200

The new B550 chipset is changing the game when it comes to AMD machines. Previously, if you wanted to take advantage of the blazing fast PCIe 4.0 SSDs, you needed an X570 motherboard, which was undeniably expensive—especially if you were looking to build a more affordable system with a cheaper Ryzen 3000 processor. The B550 line is a solid upgrade to the similarly budget-conscious B450 chipset, and this MSI board packs all the features we'll need into a compact ITX form factor. Shifting down to an ITX motherboard doesn't have to come with a noticeable drop in performance; we've picked the best components to work with this mobo.

CASE

NZXT H1 Black
$350

That's a lot of money for a case! Don't worry, though, it's justified. The NZXT H1 is the entire basis for this build: A super-compact ITX tower with an incredibly small footprint. How does it achieve such slenderness? Integrated components, that's how. Part of that $350 price tag is allocated to the 80+ Gold-rated NZXT S650 power supply, a small but mighty PSU mounted at the top of the case to save space. An AIO cooling solution is also included, routing heat away from the motherboard to a 140mm radiator and single fan. Heat buildup shouldn't be a problem here, though; the H1 has three sides with a perforated design that ensures good airflow at all times. There's even a PCIe riser strip for you to vertically mount your PSU, guaranteeing optimized use of the available space. Oh, and the H1 looks awesome and feels robust, with a frame of solid steel and a tall tempered-glass window.

CPU

AMD Ryzen 9 3950X
$700

The core of this machine is AMD's most powerful Ryzen chip, the Ryzen 9 3950X. The arrival of the 4th generation of desktop Ryzen chips is still a matter of debate, with leaks and rumors swirling, and the recent announcement of powered-up "XT" variants of the 3600X, the 3800X, and the 3900X. For now, though, this 16-core beast remains at the top of the table. A whopping 4.7GHz max boost and a tonne of cache memory makes this a content-creation powerhouse as well as a top-notch gaming CPU, and AMD's SMT technology means we've got 32 threads to play with as well. Combined with a powerful GPU, this chip should blast through most video-editing tasks and run cool thanks to a 105W TDP and its 7nm architecture.

CPU COOLER

140mm NZXT H1 AIO cooler
N/A

As we mentioned earlier, the H1 case from NZXT comes with a CPU cooler and power supply built into its chassis. These are both removable, but that's a challenging process, and it's also unlikely you'll want to use anything else; this is a high-quality AIO cooler with a 140mm NZXT fan and tubing that is exactly the right length for zero in-case slack. The single radiator is set up in conjunction with other components to promote a specific dual-chamber airflow setup, where cool air is drawn in from both sides and expelled through the perforated rear panel. It's an elegant solution for compact cooling, and the pump plate is equipped with a bracket that makes it compatible with both AMD and Intel ITX motherboards.

SSD

2TB Corsair Force MP600
$400

Okay, we might've gone a bit overboard spending money on this build. But the Force MP600 is still our favorite PCIe 4.0 drive: reliable, stupidly fast, and the attached heat sink is nice and easy to remove. When connected to a supported motherboard and CPU, this M.2 SSD reads data at almost the holy 5GB/s, and it's actually one of the more affordable 2TB drives with PCIe 4.0 compatibility. The M.2 format means there's no cables to worry about either, which is a plus in such a cramped build. Corsair guarantees that the MP600 will write up to 3,600TB of data before you ever have issues with reliability, so it's simply the best 4th-gen M.2 SSD around—at least, until the looming titan that is Samsung releases its own competition...

GPU

Nvidia GeForce RTX 2080 Super Founders Edition 8GB
$700

The professional ethos certainly applies to our GPU, the RTX 2080 Super FE. Nvidia's stripped-back aesthetic looks great, particularly the ultra-shiny mirrored centerpiece. The most RGB you'll get here is the GeForce RTX text along the side of the card, which lights up a bright green. Of course, the Founders Edition model of this top-notch GPU is something of a rare find at this point, so you will probably have to opt for a third-party manufacturer version. That's fine: Factory overclocked cards can perform better than FE models, and might come with software or aesthetic choices that you prefer. Be wary, though, as the H1 has very little room to mount a graphics card. Triple-fan cards are obviously not an option, but even some twin-fan GPUs will be too bulky for this case. Do your research first.

PSU

NZXT S650 80+ Gold
N/A

A simple but high-quality component, the S650 is a conventional SFX-L power supply, with a fully modular design and pre-routed cables inside the NZXT H1 case for minimal clutter. If you were to build an integrated-graphics system inside this case, you could strip away even more of that cabling. The S650 is (as its name implies) a 650-watt power brick, which should be more than capable of supporting our system and leaves some headroom for upgrading in the future too, in case you decide to bump up the GPU or add extra storage. Interestingly, even though the H1 case and cooler come with a three-year warranty, the S650 retains NZXT's standard warranty for power supplies: A whopping 10 years of coverage.

MEMORY

64GB (2x32GB) HyperX Predator DDR4 @ 3200MHz
$314

This is technically two items, though they'll be doing the same thing. From what we can gather, HyperX doesn't sell this exact memory kit (with a CAS latency of 16—a similar CL18 kit is available), but you can simply buy two of the 32GB 3200MHz Predator sticks separately. As long as they are identical, these should work together fine; our MSI B550i motherboard has two DIMM slots and can support a total maximum of 64GB of RAM, so it works out well. This speedy, high-capacity memory will give our machine the extra oomph it needs to power through video editing or 3D animation tasks. You'll notice a conspicuous absence of RGB lighting here, and we're going to stick to that. This is a professional build, not a flashy one.

SMALL BUT MIGHTY

A TIDY, PROFESSIONAL VIDEOGRAPHY WORKSTATION

LENGTH OF TIME: **2–3 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

1 SHIELDS DOWN

LET'S KICK THINGS OFF WITH a case stripdown. The cooler and PSU come screwed into the case, and cables are pre-routed, so there's no need to mess with them. First pop out the front glass panel and rear perforated panel. These secure the U-shaped metal casing that forms the top and side panels of the case; once they are free, it should simply lift off the frame. Carefully remove the polystyrene that's cushioning the AIO cooler.

That's all you need to do for now; removing the side panels is a completely screwless process, so ignore the tiny screws around the frame. The entire case can be disassembled (the long edges of the frame are plastic struts secured with Phillips-head screws), but that won't be necessary for this build.

4 SOCKET ROCKET

BE GENTLE WITH THE RYZEN 9 3950X. That's $700 in a tiny slab of metal and silicon. Check that the pins are undamaged on any Ryzen CPU before trying to fit it to a motherboard, as a slightly bent but repairable pin may snap and render the whole chip unusable. No, we're not speaking from experience. Anyway... lift the metal retention arm on the CPU socket and carefully drop it into place, being sure to line up the gold triangle on the chip's corner with the triangle on the corner of the socket.

This 3950X is somewhat distinct from the other 3000-series Ryzen processors we've seen; the font is subtly different, and the gold triangle is smaller. Once the chip is in place return the retention arm to its original position.

2 RADIATOR RELEASE

AT FIRST, it seems impossible to install a motherboard inside this case without removing the bulky 140mm radiator and fan entirely. Fortunately, NZXT has a nifty solution for this. Two screws at the top of the bracket securing the radiator are clearly labelled (with arrows cut into the metal!), and removing these allows the entire AIO cooler to flop down out of the case via a concealed hinge. Situate the case in an upright position and be careful when releasing the second screw, as gravity will act fast and you don't want to damage the radiator. Make sure that the CPU block and pipes are also clear of the case, but don't bend the pipes too much, as these short tubes aren't as flexible as those on larger AIO coolers.

3 MOTHERBOARD READY

LET'S GET THIS MOBO PREPPED. If you buy a new unit, the MSI B550i board should come with the standard AM4 cooler bracket (a plastic "hook" bracket on either side of the processor) already fitted around the CPU socket. If not, install that first.

This is easy enough to do; position the metal backplate beneath the motherboard so that the four screw holes line up with the four holes around the socket, then attach the two plastic brackets with the provided screws. Each bracket's "hook" should be pointed away from the processor if fitted correctly. Place your motherboard on the box it came in (or, if you have a dedicated antistatic building space, use that) and you're ready to start installing components.

5 THE RAM'S HORNS

THERE'S ONLY TWO DIMM SLOTS AVAILABLE on this B550 board, so you don't have to worry about picking the right slots for full memory speed. Release the clasps on the slots and push each stick of memory into place until it clicks, both at the clasp end and the opposite end. Both clasps should be secured, and the memory should sit flat in the slot. We are going to have to mess about in the BIOS later to ensure that our memory is running at full speed, since it'll likely default to a lower frequency like 2,400MHz.

This motherboard and processor should support the full capacity without issue, so there'll be a hefty 64GB of RAM to play with once the system is up and running.

6 LET THAT SINK IN

WE'LL BE MOUNTING the Corsair Force MP600 SSD on the motherboard, but first we're going to need to remove the heatsink that comes with it. This can be somewhat fiddly, so take care not to damage the SSD itself. The heatsink is held in place by a clasped metal bracket that also cradles the drive, but the drive is also stuck to the heatsink by a strip of adhesive thermal padding. You'll need to apply a bit of force to free the heatsink from the clasps, but the lower bracket's metal does flex a little, which should allow you to remove the sink and then peel off the bare drive. Do this last part slowly, as you don't want to tear the sticky padding and leave any bits of it stuck to the drive.

7 ARMORED UP

ONCE THE SSD IS ALL NAKED (oh my) you can install it to the motherboard. First, you'll need a small Phillips screwdriver to remove the M.2 heat shield on the board. Be careful when doing this, as it has its own tiny fan and is attached to the board via a thin cable. You don't have to disconnect this; just place the shield carefully on the board beside the M.2 slot.

The B550i comes with two standoffs pre-installed; remove the one closest to the slot. Fit the M.2 drive and gently push it down so the other end rests on the correct standoff, and secure it with one of the tiny screws included in the box. Then, remove the protective plastic from the shield's sticky pad, and line up the screw holes before sticking it in place and screwing it down.

8 MOUNTING RANGE

IT'S TIME TO MOUNT THIS MOBO. Even with the radiator out of the way, there's still little room to work here. Place the H1 on its side with the tiny motherboard plate facing upwards, and lower the motherboard assembly onto the four standoffs. These standoffs may be partially blocked by the pre-routed cables; be sure to move these so they won't be trapped underneath the board. The rear I/O shield comes pre-fitted, and it should line up with a slot on the underside of the case—more on this later.

The four screws needed to secure the motherboard are in the case accessories box. A long magnetic-tip screwdriver can make affixing these screws easier, as the cramped case makes getting your hands in close to the motherboard a challenge.

11 HINGE SCIENCE

WITH THE COOLER SECURED, it's time to get this radiator back into place. The hinged bracket lifts back up easily and only needs to be secured with the two screws removed earlier, but there's two things you need to deal with before you can do that.

First up is the pump and fan power cables; these plug in right next to each other on the motherboard. The three-pin pump connector can be plugged into the four-pin header. Secondly, the two AIO tubes need to be lowered into the case and curved outwards from the block—otherwise they won't bend safely when the radiator is returned to its original position. Place the case upright to fit the radiator, and hold it in place with one hand as you secure the first screw, otherwise it's liable to pop out.

12 VERTICAL REALITY

THE PCIE RISER should be fully secured, plugged into the mobo at one end and pre-fitted onto the frame at the other. Remove the two thumbscrews from the rear I/O slot (on the underside of the case). Turn the case sideways so the open end is facing upwards, and position the GPU inside the frame before lowering it into the slot. It should click into position, and the rear I/O should be flush with the rear opening on the case. For us this requires a lot of pressure on the card, but that might not be the case with every card. Hold the GPU in place while you replace the two thumbscrews. Once the card is secure, plug in the two PCIe power cables; only one eight-pin connector is needed, so strip away and coil the extra two-pin connector on the second cable.

9 CABLE FABLES

GETTING THE CABLING sorted is laborious. The twin PCIe power cables for the GPU should be partitioned separately into the cavity on the opposite side of the case, so leave them alone for now. Connect the pre-routed power cables to the motherboard, then the front I/O cables. Run these around the edges of the board, so that they don't get in the way when you fit the cooler and close the case. Use the velcro straps inside the case to keep the cables from resting on the motherboard components.

Since the H1 makes accessing the rear I/O tricky, you may want to leave those cables disconnected and invest in an external USB hub. Lastly, plug in the loose end of the PCIe riser. Curve it around the edge of the board to fit into the expansion slot.

10 COOL WAVES

LET'S GET THIS COOLER IN PLACE. The H1 comes with the Intel bracket pre-fitted, so remove that and replace it with the AMD version in the accessories box. This isn't complicated, but consult the H1's instructions for more detailed diagrams. The Intel bracket slides out from around the CPU block with a bit of force (the plastic casing may shift a little bit). Replace it with the AMD bracket, and attach the two clasps to either side with the long screws and sprung standoffs provided.

Once the bracket's ready, put a pea-sized blob of thermal paste on the processor and push the CPU block down over it, attaching it to the plastic "hooks" on both sides, then screw it down until it won't budge. Don't over-tighten it, though.

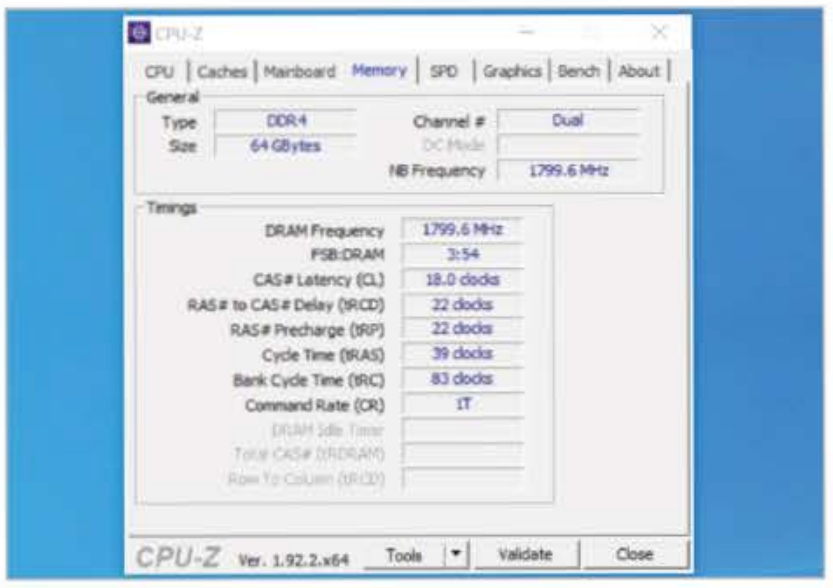
13 CLOSING TIME

WE'RE ALL DONE, so it's time to seal up this 2001-monolith-looking monster machine. Take a little time to tuck in any stray cables before closing the case. The large metal cover goes back on first, lining up with grooves on either side of the frame to slot back down into place over it. With that done, the rear panel and window pop back into place easily. All done!

Now, when setting this system up, you'll first need to put it on its side and plug in your network cable, display cable, and any USB peripherals that you're using. All of these cables can then be routed neatly out of the slot on the rear of the case once you place it upright once again.

14 UP TO SPEED

ONE LAST TASK before this system is ready to chow down on some delicious video files. That HyperX Predator memory won't run natively at 3,200MHz, so take a quick trip into the motherboard BIOS to rectify that. Thankfully it's nice and simple; fire up the BIOS by hitting F2 on boot, then turn on the first A-XMP memory overclocking profile. This should set the memory to the correct 3,200MHz frequency and give you full performance. To double-check, boot up the system proper and install Windows, then download CPU-Z from www.cpuid.com and check the memory tab. This should display half the speed, so if it says 1,600MHz, you're good to go!



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COMPACT COMPUTING CONCLUSIONS

A small machine that packs a big punch

WE'RE REALLY PLEASED with how this system turned out, because building it wasn't easy. The NZXT H1 is a fantastic case with a bunch of cool innovations that benefit its small form factor, but actually building in it is an exercise in cramped spaces and fiddly cabling. Were we to start afresh, we might wait until the motherboard cables are all in place before installing the memory, as it got in our way while we were trying to connect the ATX motherboard power cable.

Thankfully, though, once we closed the case up and plugged this bad boy in, it booted and ran perfectly straight away. Praise be! All too often we have to delve back in to rectify a little mistake that prevents a boot. Not this time around, though. We got our peripherals and monitor set up and boom, the pre-loaded copy of Windows 10 on the Corsair Force MP600 is up and running.

The first thing we noticed is the noise. Yes, this build isn't exactly quiet, although it obviously pales in comparison to bigger, beefier machines. The main offender here is the Nvidia RTX 2080 Super FE; the flat twin fans are quite loud, though only when the card is running at load. We detect a faint bit of pump whine from the AIO cooler too, although the 140mm radiator fan seems to run quietly. The system makes very little noise when idling or during low-intensity tasks.

The Ryzen 9 3950X demolishes our benchmarks, as expected. This 16-core beast chews through CPU-bound tasks with ease, nailing great scores in Cinebench and Fry Render, among others. Gaming performance still lags a bit behind Intel, but this will only affect CPU-bound titles like *Total War: Warhammer II*. General graphical performance in games and real-time rendering is fantastic, which is no surprise given the powerful GPU we're using. However, a factory-overclocked model of the RTX 2080 Super from a third-party manufacturer is liable to perform better.

In fact, we had originally planned to use an MSI graphics card for this build. All was going well until we reached Step 12... then couldn't fit the GPU inside the case. We tried everything: Removing the front I/O to clear some room, unscrewing the PCIe riser to plug it in before trying to mount the card, even disassembling the entire top half of the case. Nothing worked. But we'd checked the height clearance! Turns out that wasn't our problem, though. The card we had initially chosen was too wide for the space. Learn from our mistakes, dear readers—find a compact card.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Single (Index)	192	214 (11%)
Cinebench R15 Multi (Index)	2,952	3,985 (35%)
TechARP x264 (fps)	61.08	79.09 (29%)
Fry Render (m:s)	1:17	1:10 (9%)
AIDA64 Memory Bandwidth (MB/s)	55,051	38,961 (-29%)
AIDA64 Memory Latency (ns)	71.4	93.9 (-32%)
SSD 1: CrystalDisk QD8 Sequential Read (MB/s)	4,992	4,924 (-1%)
SSD 1: CrystalDisk QD8 Sequential Write (MB/s)	4,284	4,252 (-1%)
SSD 1: CrystalDisk QD1 Random 4K Read (MB/s)	60	46 (-23%)
SSD 1: CrystalDisk QD1 Random 4K Write (MB/s)	220	237 (8%)
Adobe Premiere Pro 5-Minute 4K Render (m:s)	1:19	1:11 (10%)
Adobe After Effects 10-Second 4K Render (m:s)	6:14	5:27 (13%)
Total War: Warhammer II (fps)	54	46 (-15%)
3D Mark: Firestrike (Index)	21,453	24,539 (14%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 9 3900X, 32GB (4x8GB) G.Skill Trident Z RGB Neo @ 3600, an EVGA GeForce RTX 2080 Super XC Ultra, and a 1TB Corsair Force MP600 M.2 PCIe 4.0 SSD. All game tests were performed at 3440x1440 on Ultra.

ALL-ROUND PERFORMER

Anyway... back to assessing this build's performance. It's great across the board, really: Renders are speedy, and file transfers are more or less as fast as you're going to get. The Force MP600 SSD gets mighty close to that coveted 5GB/s, although performance is a smidge lower than we were expecting: Probably because this B550 board can't handle the drive quite as well as a more expensive X570. Still, you're not likely to notice any difference in practice. The MP600 remains blazing fast, streamlining bulk data transfers and trivializing load times in games.

One area our system seemed to fall down on was memory performance.

Although it wasn't bad, the bandwidth tested in AIDA64 was lower than we had hoped for, and the real-world latency wasn't exactly impressive either. Our memory was running at full speed (as confirmed by CPU-Z) and we double-checked that the MSI motherboard was definitely capable of fully supporting this RAM. This is our first time using a B550 board, and an ITX model at that, so it could be that these new budget boards just don't handle high-capacity memory too well. Alternatively, the problem could lie with the memory itself; broadly speaking, we'd recommend you buy a proper kit of two. HyperX did actually send us our two in a single box, but we couldn't find such a kit available anywhere online.

In any case, overall performance was solid. This system has all the hardware necessary to handle even the most demanding videography tasks from the comfort of your home office, and it certainly won't take up much space. Compared to the previous machine on our test bench (read: dinner table)—last issue's audio-recording build—the difference is night and day. The H1's smart routing means that the cables for our peripherals and monitor neatly run from the rear of the base. The OS boot speed is delightfully fast.

This system runs cool, too; pushing the processor to the limit didn't see much time spent in excess of 60C. That single-fan AIO is clearly working some serious overtime, doing plenty to justify the H1's overall price. The metal outer casing felt ice cold even after we'd blown through multiple repeated benchmarks, demonstrating that NZXT's dual-chamber airflow design really works.

While we did play around with overclocking, the best option is simply to use AMD's Ryzen Master software for auto-overclocking. We were just about able to hit a stable 4.2GHz overclock manually, but the automated alternative reliably gave us 4.3GHz at load and is gentler on the processor. Auto-overclocking did still see a significant temperature increase, but nothing to be concerned by. Ryzen Master's primary benefit was in single-core performance, which is effectively lost if you choose to overclock manually.

LOOK TO THE FUTURE

There's some potential for upgrades here too. While a 2TB M.2 drive is nice, anyone who works with 4K video will know that it likely won't be enough in the long run, especially if you'd like to keep a few games on your system too (looking at you, *Call of Duty*). There's one extra aspect of the NZXT H1 we've yet to mention: The toolless SSD tray. This makes installing an extra SATA SSD or two a cakewalk, and with Samsung promising cheaper 8GB 2.5-inch drives in the near future, we might consider calling time of death on HDDs in high-end systems.

Upgrading the graphics card is also a straightforward process, as it's only secured by two thumbscrews and a small clasp on the PCIe riser. The 2080 Super is a fairly future-proofed choice of GPU, but should you feel a burning desire to upgrade once the inevitable RTX 3000 series arrives, it won't be difficult to do so. The S650 power supply means that there's a reasonable amount of headroom when it comes to power.

Changing components like the SSD and processor will likely prove more challenging, but both are high-quality choices so we feel confident that they'll last a while. If you do need to upgrade the PSU to allow sufficient wattage for your upgrades, brace yourself for a challenge. The plastic frame of the case needs to be partially disassembled in order to detach the PSU shroud and access this compact power brick.

As a finished build, it doesn't look like much. The window of the H1 matte black edition is tinted, providing very limited views inside, but there's not much to see when it's removed anyway: Just the edges of the GPU and motherboard, and the solid black metal of the PSU shroud, with some black cables packed tightly around it all. That's perfect, though; this system oozes clean professionalism, and would look equally good in a small home study or an open-plan office. Mission accomplished.

1 The PSU is neatly cradled inside this metal shroud attached to the roof of the case. It can be replaced with a different SFX power supply, but be warned: It's a laborious process.

2 This particular GPU fits snugly in the allocated space, but those Founders Edition fans are certainly quite noisy when they're working hard.

3 Making the rear I/Os virtually inaccessible during normal use is a bold move on NZXT's part, but if you prep your workspace well enough it shouldn't be a problem.

MAXIMUM BENCHMARKING

Zak Storey takes you behind the scenes of our testing plans for 2020 and beyond

GOOD-QUALITY TECH JOURNALISM starts with a solid, objective testing platform, there's no doubt about it. However, in print things are more complicated than in the world of digital. There's a very fine balancing act that needs to be performed: Resources and budgets are less readily available here, and time and space far more limited. Fixed print deadlines and word counts are incredibly restrictive, and because of that we can't just throw pages and pages of benchmarks at you, without sacrificing quality content elsewhere; whether that's the fantastic photography our art division produces, or the intricately woven literary entertainment, knowledge, and opinions of our writers. Finding the perfect balance between it all is key.

Maximum PC's current set of benchmarks and zero-points have been getting somewhat long in the tooth, and frankly they could really do with a good ol' refresh. To that end, this time around we're going to take you on a complete tour of what tests we're going to be introducing in the coming months, how we'll be testing our hardware, and what we plan to do with the results once we're done.

So if you're curious about where we're heading, or interested in learning how to benchmark your own machine, then it's time to turn the page and enter into the wondrous realm of synthetic and real-world tests you need to know about for the next few years.

Proving Processor Performance

AS INTEL CONTINUES to push the limits of 14nm, and Ryzen prefers to do its own thing, we feel that overclocking outside of the world of LN2 is effectively dead for the majority of enthusiasts. For that reason OC benchmarks are out of the window straight away. That's not to say we won't try overclocking, rather that it's something we'll refer to in the copy. Instead, we will report on what exactly the maximum clock speed achieved is at stock for both single and multi-core performance under load.

For our synthetic tests, Cinebench R20, HWBOT x265 @ 4K, and HEVC's H.265 Decode @ 1080p are perfect. These three tests deal with rendering, encoding, and decoding. The latter two use different file formats and resolutions to better replicate what most professionals are using in the digital world.

Moving on to our memory tests, and because memory bandwidth is mostly attributed to the number of memory channels supported and memory speed, we're going to skip that. Instead, what does matter is memory latency, as it gives us an idea of how the core structure is set up. AIDA64 Extreme's Memory Latency test is perfect for that.

The most interesting tests for us revolve around power draw and temperature. For this we're going to use Prime95, HWMonitor, and a handy watt meter to get the results we need. We'll run one instance of Prime95's blend test and measure the maximum temperature and wattage pulled over a 10-minute run.

After that we move on to our real-world testing for gaming, video-rendering and editing. We're running two AAA titles—*Total War: Three Kingdoms*, and *Assassin's Creed Odyssey*, both at 1080p. *Total War* has always been a CPU-dependent title regardless of resolution, whereas *Assassin's Creed* is the opposite, giving us a good spread as to how valuable the CPU is in the gaming department.

Then lastly we have our two Adobe real-world tests. With Premiere we'll be rendering out a basic, five-minute video @ 4K, and then with After Effects we'll render a freely available 10-second 4K intro template, and time both to give us a good guide as to how these processors perform under real-world conditions.

PROCESSOR BENCHMARKS

	Product Name	Product Name
Cinebench R20 Single/Multi (Index)	**00/00**	00/00
Max Sustained Single/Multi Clock Speed (MHz)	**00/00**	00/00
HWBOT X265 @ 4K (fps)	**00**	00
HEVC H.265 Decode 1080p @ 25Mbps (fps)	00	00
AIDA64 Memory Latency (ns)	0.0	0.0
3DMark: Fire Strike @ 1080p (Index)	00	00
Total War: Three Kingdoms @ 1080p (fps)	000	000
Assassin's Creed Odyssey @ 1080p (fps)	000	000
Adobe Premiere Pro Benchmark @ 4K (m:s)	0:0	0:0
Adobe After Effects Benchmark @ 4K (m:s)	0:0	0:0
Power Draw Prime95 Idle/Load (w)	00/00	00/00
Max Temp Prime95 Idle/Load (C)	00/00	00/00

Best scores are in bold. Our test bed consists of .....

Graphics Card Benchmarks

FOR THE MAJORITY of people, a good GPU is all about gaming, but that's not the only area where they're effective. In computational tasks with large datasets, and in video-rendering programs, having a good graphics card is key. To that end we've dramatically readjusted how we're going to be testing these cards.

For synthetic benchmarks, we're running the tried and true 3DMark tests, including Fire Strike for DX11 and Port Royal for RTX (or ray tracing), all at 1080p. What we're looking for is a fixed figure to compare graphics cards across multiple generations without having to worry about resolution-based bottlenecks.

Moving on to the games, and this time we've picked four AAA titles. We'll test each card with these games at a resolution that's appropriate for the card itself. These titles are *Total War: Three Kingdoms*, *Metro Exodus*, *Red Dead Redemption II*, and *Assassin's Creed Odyssey*, all of which have in-built benchmarks. However, with *Assassin's Creed* we will be swapping this out for the latest title, *Valhalla*, when that launches.

We've also added CompuBench 2.0's N-Body Simulation 1024K, an OpenCL benchmark primarily used to showcase N-Body physics simulations. It spits out a number based on how many iterations/sec the GPU can produce. These kinds of simulations mimic a system of particles and bodies under the effects of gravity in a vacuum, and are used in astrophysics with large datasets. We've also added FAHBench. This is another OpenCL test that mimics workloads assigned during Folding@Home tasks to identify how well a GPU can simulate molecular dynamics. On top of that, we've included the same Premiere Pro and After Effects benchmarks we're using in our CPU testing.

For temperature and power testing, we're going to pull figures during a run of 3DMark: Fire Strike @ 1080p. We'll run a custom, repeating, combined test for 10 minutes, noting down max temp and watts drawn from the wall.

GRAPHICS CARD BENCHMARKS

	Product Name	Product Name
3DMark: Fire Strike (Index)	**00**	00
3DMark: Port Royal Ray Tracing (Index)	**00**	00
Total War: Three Kingdoms (fps)	**00**	00
Assassin's Creed Odyssey (fps)	00	00
Metro Exodus (fps)	00	00
Red Dead Redemption II (fps)	00	00
CompuBench 2.0 N-Body Simulation 1024K (Iterations)	000	000
FAHBench (Index)	000	000
Adobe Premiere Pro Benchmark @ 4K (m:s)	0:0	0:0
Adobe After Effects Benchmark @ 4K (m:s)	0:0	0:0
Power Draw Idle/Load (W)	00/00	00/00
Max Temp (C)	00	00

Best scores are in bold. Our test bed consists of .....

Chassis Benchmarks

YEP, WE'RE FINALLY going to introduce chassis testing. System-building is hugely important to us, and we feel it's about time we introduce our own case testing.

Not only are we going to test these cases in their stock, shipped configurations, with whatever fans are (or are not) included, but we'll also test them in an optimized configuration too. So how will we do it? Well firstly it's all about hardware. Since we'll be testing everything from ITX cases to full towers and beyond, we're going to need two very similar test beds at two different form factors. Before we test, we'll manually "overclock" the CPU to 4.5GHz @1.2V, and set the GPU to run at a fixed max clock speed of 1,750 MHz. This will eliminate fluctuations in temperature output at lower or higher ambient temps.

For cooling, our "stock" configuration is going to use a Noctua NH-U12S air-tower equipped with twin Corsair ML120 Pro fans. In very extreme ITX cases we'll be swapping that out for a Noctua NH-L9i, which is a super-slim cooler, although

Motherboard Benchmarks

MOTHERBOARDS ARE WHERE things get surprisingly interesting. We're seeing manufacturers tweak their boards and push more voltage into certain areas at stock, so it's vital that we keep a vigilant eye on that. That way you can stay informed and decide whether you want to purchase a motherboard that might give you more stock performance in favor of more heat and a shorter life cycle, or vice versa. To help identify those situations, we've included a bevy of benchmarks aimed at every area of system use.

We're expanding our traditional synthetic rendering performance test, Cinebench R20, to not only include multi-core but also single-core performance. While this is running, in a similar manner to our CPU benchmarks, we're also going to measure max sustained single and multi-core clock speeds. Although we're not swapping out processors, this will give us an indicator as to the stock auto-overclocking performance of the board.

We've picked up AIDA64 again for memory latency, and this time bandwidth

CASE REVIEW TEST BEDS

CPU	Intel Core i9-9900K @ 4.5 GHz
ITX Motherboard	Gigabyte Z390 I Aorus Pro Wifi
ATX Motherboard	Gigabyte Z390 Aorus Pro Wifi
RAM	16GB (2x8GB) Corsair Vengeance LPX
GPU	Nvidia GeForce GTX 1080 FE
SSD	512GB Corsair Force MP510
ITX PSU	Corsair SF750 80+ Platinum
ATX PSU	Corsair HX750i 80+ Platinum

CASE BENCHMARKS

	Product Name	Product Name
STOCK		
Idle / Load CPU Temperature (C)	**00/00**	00/00
Load CPU Temp Delta @ Ambient (C)	**00**	00
Idle / Load GPU Temperature (C)	00/00	00/00
Load GPU Temp Delta @ Ambient (C)	00	00
OPTIMIZED		
Idle / Load CPU Temperature (C)	00/00	00/00
Load CPU Temp Delta @ Ambient (C)	00	00
Idle / Load GPU Temperature (C)	00/00	00/00
Load GPU Temp Delta @ Ambient (C)	00	00
NOISE		
Stock / Optimized Noise (DB(A))	00/00	00/00

Best scores are in bold. Our test bed consists of .....

those cases will only ever be compared against other L9i-tested chassis.

Once temperature testing is completed at stock, we'll swap out the cooler for a Corsair Hydro H100X 240mm AIO, and install the cooler with those same two fans for consistency. Then we'll install up to eight 120mm ML120 fans in what we consider to be the best orientation.

For temperature tests for the CPU we'll note the ambient temperature and humidity, before running an instance of Prime95 for an hour, and noting down the max CPU temperature. We'll then let the system idle for 30 minutes, before performing a Fire Strike "Combined" loop test for an hour, noting the max GPU temperature. We'll then use a phone app to measure dB(A) during 50% system fan RPM under load in an empty room from three feet away. Including temperature deltas against ambient for both components will account for fluctuation in ambient heat.

MOTHERBOARD BENCHMARKS

	Product Name	Product Name
Cinebench R20 Single/Multi (Index)	**00/00**	00/00
Max Sustained Single/Multi Clock Speed (MHz)	**00/00**	00/00
AIDA64 Memory Latency (ns)	**0.0**	0.0
AIDA64 Memory Bandwidth (MB/s)	00	00
CrystalDiskMark 7.0 Sequential Read/Write QD8 M.2 (MB/s)	00/00	00/00
CrystalDiskMark 7.0 Random 4K Read/Write QD1 M.2 (MB/s)	00/00	00/00
Adobe Premiere Pro Benchmark @ 4K (m:s)	0:0	0:0
Assassins Creed Odyssey @ 1080p (fps)	000	000
Max CPU Temp Prime95 Idle/Load (C)	00/00	00/00
Max VRM Temp Prime95 Idle/Load (C)	00/00	00/00
Power Draw CPU Idle/Load (W)	00/00	00/00
Power Draw Combined Load (W)	000	000

Best scores are in bold. Our test bed consists of .....

too, followed by CrystalDiskMark 7.0 to identify potential problems with PCIe SSDs.

From there we move into some real-world testing, again throwing in a run of our now-staple Adobe Premiere Pro Benchmark @ 4K. We're not expecting massive differences here with render time, but if the board is auto-overclocking more than it should, and we're getting higher temperatures and higher synthetic results but not seeing a decrease in render time here, then there's a problem.

To capitalize on all that we've also paired it with an extensive array of power draw and temperature tests. We'll be using a 10-minute run of Prime95 Blends test to note the max CPU temperature and max VRM temperature, and then using that same run to identify CPU power draw from the wall under load. Finally, we'll perform one last run on 3DMark: Fire Strike, running a looped "Combined" test for 10 minutes, noting the max wattage drawn from the wall to better simulate intense gaming loads.

The Future of Test Beds

WITH NEW BENCHMARKS comes a need for new zero-points and test-beds. Not only is this a pivotal step for our reviews, but it's also important for our system builds as well. Test-beds are fairly complex things to organize, as you need to have some flexibility in them while also trying to keep them as closely aligned as possible to one another to reduce inconsistency. For instance, when testing AMD and Intel processors, if we're comparing them to one from the competition, it's ideal if we have motherboards that cost roughly the same, from the same manufacturer, with a similar feature-set across the two platforms. Then it's all about pairing that with a single high-end GPU (in this case an RTX 2080 Super), two separate but identical SSDs for the OS (one install for AMD, and one for Intel) to avoid chipset and program conflicts, and then the same memory kit as well, in this case 32GB (2x16GB) of DDR4 @ 3600MT/s.

Moving to graphics cards and SSDs, however, complicates things. GPUs have typically always performed better with Intel processors due to higher IPC and single-core performance. Ryzen's certainly come a long way since it first debuted, but it's still slightly behind its blue competitor. But AMD has one trump card in its arsenal, and that's the fact it's the only platform right now that supports PCIe 4.0, doubling the effective bandwidth of any device that uses the connection standard compared to last gen.

There are two reasons why that's important, and why for the first time in over a decade we're turning to AMD for our graphics card testing. We expect that within the next 12-24 months to see the first PCIe 4.0 graphics cards emerge, especially as RTX matures in its second iteration. Committing time to testing GPUs on a PCIe 3.0 platform, and then needing to retest our entire inventory when the new cards launch is just not feasible. On top of that, there's already a plethora of PCIe 4.0 SSDs on the market. So if we can keep a single high-spec platform available for both SSD and GPU testing together, it saves time and energy stripping down parts off of the test bench.

GAMING SYSTEM BENCHMARKS

	ZERO-POINT	
Cinebench R20 Single (index)	00	000 (00%)
Cinebench R20 Multi (index)	00	000 (000%)
CrystalDiskMark 7.0 Sequential Read QD8 M.2 (MB/s)	00	00 (-00%)
3DMark: Fire Strike (Index)	00	000 (00%)
3DMark: Port Royal Ray Tracing (Index)	00	00 (0%)
Total War: Three Kingdoms (fps)	00	00 (-00%)
Assassins Creed Odyssey (fps)	00	00 (-00%)
Metro Exodus (fps)	00	000 (000%)
Red Dead Redemption II (fps)	00	00 (-00%)
Adobe Premiere Pro Benchmark @ 4K (m:s)	00	000 (000%)
Power Draw Fire Strike Combined (Load) (W)	00	000 (000%)
Max CPU Temp Fire Strike Combined (Load) (C)	00	00 (-00%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the .....

WORKSTATION SYSTEM BENCHMARKS

	ZERO-POINT	
Cinebench R20 Single (Index)	00	000 (00%)
Cinebench R20 Multi (Undex)	00	000 (000%)
HWBOT X265 @ 4K (fps)	00	00 (-00%)
3DMark: Fire Strike (Index)	00	000 (00%)
AIDA64 Memory Bandwidth (MB/s)	00	00 (0%)
CrystalDiskMark 7.0 Sequential Read QD8 M.2 (MB/s)	00	00 (-00%)
CrystalDiskMark 7.0 Sequential Write QD8 M.2 (MB/s)	00	00 (-00%)
CompuBench 2.0 N-Body Simulation 1024K (Iterations)	00	000 (000%)
FAHBench (Index)	00	00 (-00%)
Adobe Premiere Pro Benchmark @ 4K (m:s)	00	000 (000%)
Adobe After Effects Benchmark @ 4K (m:s)	00	000 (000%)
Power Draw Fire Strike Combined (Load) (W)	00	00 (-00%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the .....

Zero-Points

ZERO-POINTS ARE fixed systems that we compare our system builds against. When we last overhauled the benchmarks, we actually moved away from using a single overly expensive zero-point, to using three different ones instead. These systems were aimed at three different price points, with different gaming resolutions in mind (1080p, 1440p, and 4K), and loosely based on our Blueprints section.

Now we know that not everyone plays games, but gaming PCs are typically jack-of-all-trades when it comes to other computational tasks. They can handle anything you throw at them, but obviously not to the same degree as a machine specialized towards a particular purpose. To that end, if we do build a very specialist workstation rig, comparing it against a system like this gives us a good insight as to just how much performance is gained for that extra investment.

To that end, we'll be introducing a brand new set of ZPs for build-it and feature systems. We're not quite sure what they're going to contain just yet, as we're still working out the details with a new retailer to help support us.

BENCHMARK YOUR SSD PG.50

Laptops

NOTEBOOKS AND LAPTOPS present a particularly interesting challenge. The difference in performance levels when comparing a $2,000 Ultrabook to a gaming notebook can be night and day: One is designed to function as a lightweight portable office PC, whereas the other has more in common with a full-fledged desktop. Combine that with the myriad form factors affecting the amount of space manufacturers have to include cooling and hardware, and picking a standard set of zero-points for laptop reviews becomes increasingly difficult.

To get around this, we've decided to choose four separate laptops to act as our zero-points, with two separate sets of system benchmarks (although more on that later). Two of these will be gaming notebooks, and two of them ultrabooks, with each series featuring one product at $1,000, and the other $1,800. We'll be running the following:

ULTRABOOKS

- **Acer Swift 5 14-inch $1,000**
- **HP Spectre x360 13-inch $1,800**

GAMING NOTEBOOKS

- **Acer Nitro 7 15.6-inch $1,000**
- **Alienware M15 R1 15.6-inch $1,800**

System & Laptop Benchmarks

LAST BUT BY NO MEANS LEAST, we have our system and laptop benchmarks. Following a similar line to our laptop zero-point logic above, we're now going to include two sets of separate system benchmarks, dependent on whether the system built is aimed at workstation tasks or gaming. These are effectively an amalgamation of all of the benchmarks we've mentioned before for CPUs, GPUs, and motherboards, with a few slight tweaks to the laptop benchmarking process compared to the systems, purely based on form factor limitations, and what you'll likely be doing with these devices.

The End Goal

THIS IS quite an extensive remodel for our testing methodology. Not only does it expand on what sort of tests we were doing prior to this, but it also should help to give you and us a lot more insight into how well these products function.

However, we're not just stopping there, and we absolutely understand the limitations of our print magazine when it comes to finding old content. So what we're going to do is provide you with a handy little URL here: https://bit.ly/MPC-BMDB. This is going to be *Maximum PC*'s Public Benchmark Database.

Not only will you find all of the benchmark results from every zero-point, system, and product we've tested going forward, but you'll also find our complete testing methodologies as well, so you can run these same tests on your own systems at home, in exactly the same manner that we do here. Of course, we'll still have our own internal databases for NDA'd product launches and releases, but as soon as the magazine goes on sale, the latest benchmark results from that issue will be added to the database for your own reference.

So what's the catch? Well this is going to be a work in progress for some time. We're sadly still writing this during our own company's lockdown, and with limited office access. We hope to be back in the office with all of our testing capacity ready for by the time you're reading our November and December issues.

GAMING LAPTOP BENCHMARKS

	ZERO-POINT	
CineBench R20 Single (Index)	00	000 (00%)
CineBench R20 Multi (Index)	00	000 (000%)
CrystalDiskMark 7.0 Sequential Read QD8 M.2 (MB/s)	00	00 (-00%)
3DMark: Fire Strike (Index)	00	000 (00%)
3DMark: Port Royal Ray Tracing (Index)	00	00 (0%)
Total War: Three Kingdoms (fps)	00	00 (-00%)
Assassins Creed Odyssey (fps)	00	00 (-00%)
Metro Exodus (fps)	00	000 (000%)
Red Dead Redemption II (fps)	00	00 (-00%)
PCMark 10 - Applications Benchmark (Index)	00	000 (000%)
PCMark 10 - Battery Life (h:m:s)	0:0:0	000 (000%)
Max CPU Temp Fire Strike Combined (Load) (C)	00	00 (-00%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the .....

ULTRABOOK BENCHMARKS

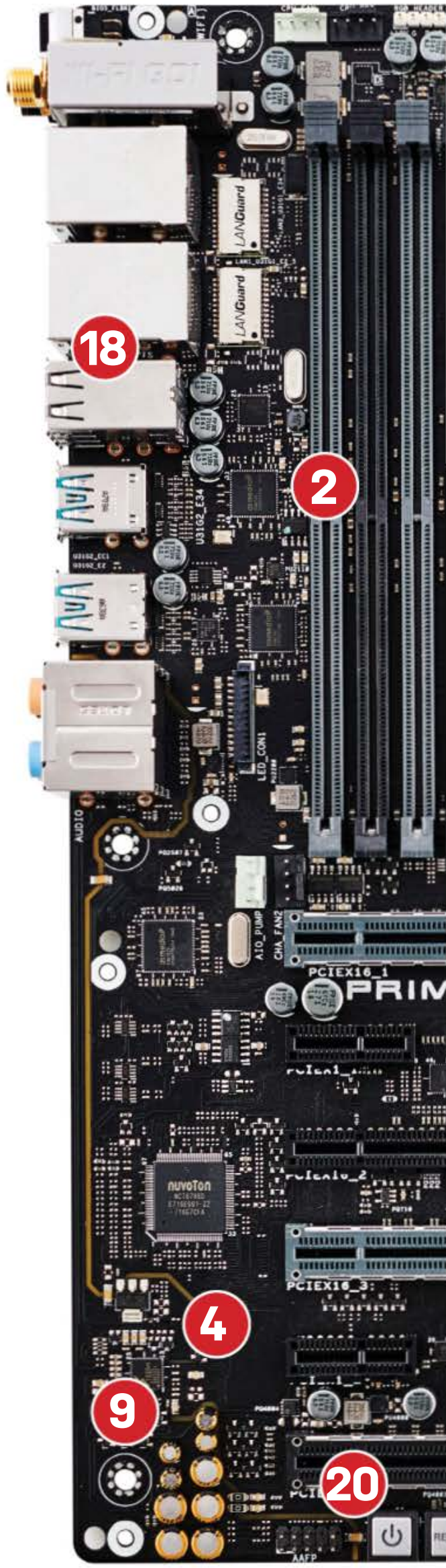
	ZERO-POINT	
CineBench R20 Single (Index)	00	000 (00%)
CineBench R20 Multi (Undex)	00	000 (000%)
HWBOT X265 @ 4K (fps)	00	00 (-00%)
AIDA64 Memory Bandwidth (MB/s)	00	000 (00%)
CrystalDiskMark 7.0 Sequential Read QD8 M.2 (MB/s)	00	00 (0%)
CrystalDiskMark 7.0 Sequential Read QD8 M.2 (MB/s)	00	00 (-00%)
3DMark: Fire Strike (Index)	00	00 (-00%)
Adobe Premiere Pro Benchmark @ 4K (m:s)	0:0	000 (000%)
Adobe After Effects Benchmark @ 4K (m:s)	0:0	00 (-00%)
PCMark 10 - Applications Benchmark (Index)	00	000 (000%)
PCMark 10 - Battery Life (h:m:s)	0:0:0	000 (000%)
Max CPU Temp Fire Strike Combined (Load) (C)	00	00 (-00%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our gaming laptop zero-point is the .....

MOTHERBOARDS UNWRAPPED

Gavin Bonshor breaks down just what makes your mobo tick, in this primer on the computing world's most underlooked piece of tech



LET'S FACE IT, much of the buzz surrounding product launches of new CPU architectures revolve around core count, thread count, clock speed, turbo clock speed, supported memory speeds—you name it. However, if the CPU is the engine of a system, then the motherboard is the manifold without which nothing would function.

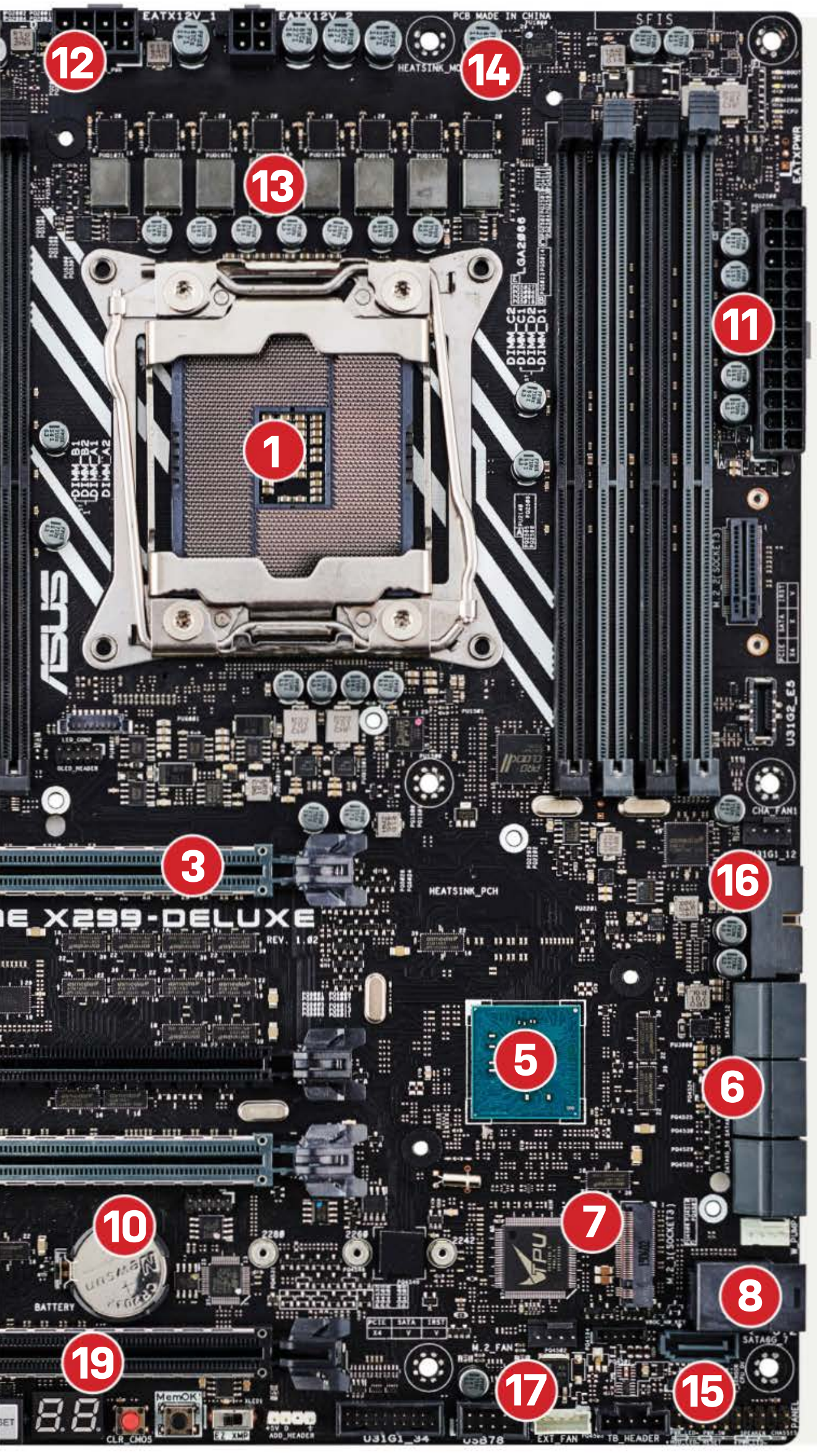
With so many different key components that make up a computer system, the motherboard is the central hub that binds and connects the processor to the graphics card, memory, storage, and so on. Not only that, but it also connects a whole host of controllers from the motherboard chipset to the CPU, which essentially manifests into input and output, such as USB ports, audio jacks, M.2 slots, networking controllers like Ethernet and Wi-Fi, and even Thunderbolt 3 on premium models. At the launch of every new chipset, motherboard vendors release swathes of models, from the more budget-focused to the highly premium that are decked out with more features than you can shake a stick at.

The core fundamental aspects of a motherboard consist of much the same across all models, whether that's an AMD or Intel-based board, with each motherboard vendor implementing its own aesthetic and feature sets based on support from both the processor and the motherboard chipset.

In this issue, we're going to take a journey through how a motherboard "works," what components make up a conventional consumer-level desktop motherboard, and why each component is important.

THE MODERN MOTHERBOARD
A BASIC DIAGRAM

One of our favorite quips within this industry is that "no motherboard is created equally," and although true to a certain degree, in this instance it doesn't have much swing. This is because each desktop motherboard has the same core characteristics that makes it a motherboard, and that remains the same



ASUS PRIME X299-DELUXE MOTHERBOARD

1. CPU socket
2. Memory slots
3. PCIe x16 slot
4. PCIe x1 slot
5. Chipset
6. SATA ports
7. M.2 slot
8. U.2 port
9. Audio codec
10. CMOS battery
11. Motherboard 12 V ATX power connector
12. CPU 12 V ATX power connector
13. Power delivery/ VRM
14. Fan header
15. Front panel header
16. USB 3.x header
17. USB 2.x header
18. Rear panel I/O
19. LED debug
20. Power/Reset buttons

across each platform regardless of processor, brand, or chipset model. Let's have a look at a typical motherboard and its most commonly associated and distinctive features.

Each motherboard will include a different feature set, and as a result will include different headers—some more and some less—especially when compared with the premium ASUS Prime X299-Deluxe motherboard we've illustrated above. This includes things like M.2 slots, with some models opting for one, and some even managing to include three or four. Parts including Power/Reset buttons and LED debuggers are more commonly found on premium models, and are omitted from a lot of budget-focused models primarily due to cost.

Now let's take a dive into some of the more intricate motherboard characteristics and commonly used terminology, and what it means.

FORM FACTOR SIZE MATTERS

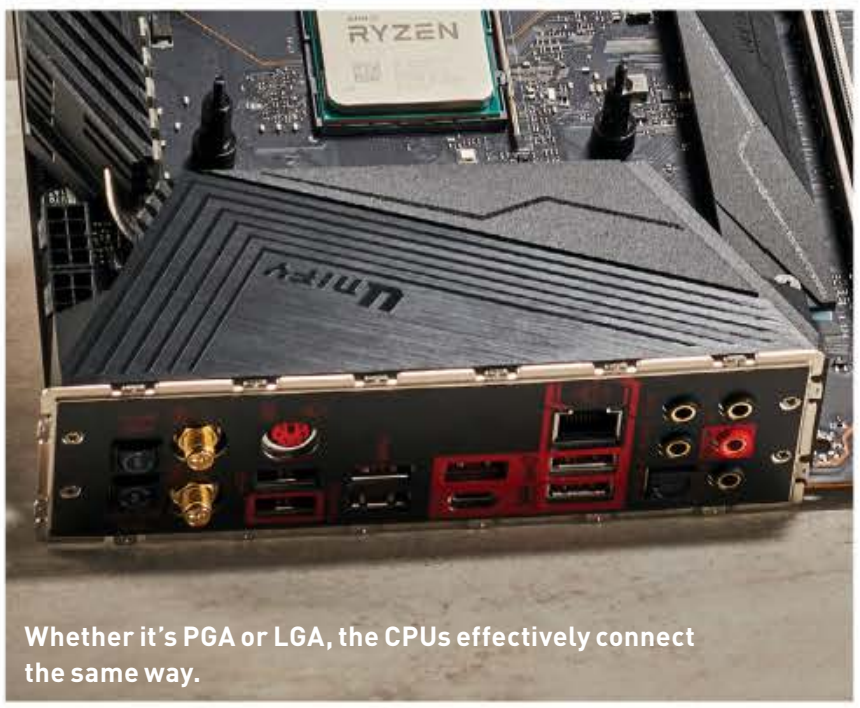
When it comes to motherboards and deciding which one is the right one for the job, the form factor is one of the most important aspects for a multitude of reasons. Firstly the form factor relates to the size of the motherboard, with the most common form factors consisting of ATX, micro-ATX and mini-ITX. Each includes its own set of characteristics, as the smaller the motherboard, the less that can be placed onto it. Technically speaking, a mini-ITX system will have a smaller desktop footprint than that of an ATX-sized PC, and will restrict things like memory capacity and expansion slot (PCIe) support. The dimensions of the three most common form factors are as follows:

- **ATX – 12 x 9.6 inches**
- **Micro-ATX – 9.6 x 9.6 inches**
- **Mini-ITX – 6.7 x 6.7 inches**

EXPANSION SLOTS THE TL:DR ON PCIE

Related to sizing, each motherboard includes an array of expansion slots, with PCIe x16 slots or full-length slots for devices such as graphics cards, and PCIe x1 slots for things like network controllers, SATA controllers, and premium sound cards. Each motherboard chipset and CPU has a limited amount of PCIe and high-speed input and output (HSIO) lanes, which determine how many slots can be implemented and how they can be used. A common example of this is multi graphics card support, which will require two or more full-length PCIe slots, with AMD Crossfire two-way requiring a minimum of PCIe x4 to operate, and Nvidia SLI demanding at least PCIe x8. On more recent models, there is support for the PCIe 4.0 standard (here's looking at you AMD Ryzen 3000), which is the latest and greatest, but there is still little in the way of components on the market to fully utilize the extra bandwidth available. Most motherboards on the market include PCIe 3.0, although it is backwards compatible, meaning a PCIe 3.0 card could be placed into a PCIe 4.0 slot, but it would just operate at PCIe 3.0 speeds. Some older models and the cheapest of the cheap sometimes include PCI slots, which is an older standard and virtually non-existent in today's ever-evolving industry.

Expansion slot connection standards have been backwards compatible since PCIe 2.0.



Whether it's PGA or LGA, the CPUs effectively connect the same way.

CPU SOCKET LGA AND PGA

One of, if not the most important trait of a motherboard is the CPU socket, as this is where the PC's brain and engine rests. For consumer models, there are two primary socket types: LGA, or land grid array; and PGA, also known as pin grid array. AMD has opted for a PGA socket that, when reverting to basics, means the pins are on the CPU, with pin slots in the socket, for example socket AM4. For as long as we've been using computers, Intel has used an LGA design, which means the pins are in the socket.

Regardless of whether or not the pins are in the CPU socket or on the CPU itself, these are very fragile, and one slight knock or slip can result in dead hardware. To make the installation of CPUs easier, Intel LGA sockets use a mechanism and latch to create compression force when installing it, with a notch to show which way the processor is installed. For AMD, there is a similar notch or arrow in one of the corners of the CPU, and it uses a

The chipset is an important component, as it handles all the connectivity that the CPU doesn't.

In a VRM, the cylinders are the capacitors, the rectangles are the chokes, and the chips next to the chokes are the power stages or phases.

handle to release and hold the CPU in place. It's worth noting that most manufacturers don't include installation socket damage in their warranty cover, so great care must always be taken when installing the CPU.

CHIPSET WHAT IS THE CHIPSET?

The second most important and functional part of a motherboard is the chipset. There are various chipset types, each with its own set of support, including PCIe, SATA, USB, and on newer chipsets, integrated networking PHY or a physical layer. The term chipset is a far-reaching term and in itself, acts as the adhesive and communication hub between the CPU and the motherboard's componentry, including slots, and input and output.

While the CPU is by far the most influential common denominator in regards to overall system performance, it drives the PCIe x16 slot and—using the AMD Ryzen 3950X processor as an example—includes integrated PCIe 4.0 lanes. The latest performance chipset from AMD, the X570 chipset, includes PCIe 4.0 lanes within it, which enables users to benefit from PCIe Gen4 M.2 SSDs for trailblazing read and write performance. The most recent chipset from AMD is the B550 chipset, which is a watered-down and budget version of the X570 chipset, but instead of PCIe 4.0, it uses PCIe 3.0 in the chipset.

This is important to know. Generally speaking, the top full-length PCIe slot will always be driven by the PCIe lanes from the CPU, and on premium models, the second full-length slot too. This also includes the top M.2 connector, which is generally powered by the CPU too. Expansion slots, such as additional full-length PCIe slots outside of the top or top two, and PCIe x1 slots are all controlled from the chipset. The chipset also controls a motherboard's core SATA ports and additional M.2 slots.

CHIPSET SUPPORT BUDGET, PERFORMANCE AND HEDT

Another important thing to note is that some processors will only work with certain motherboard chipsets, even including those that feature the same socket type, for example Intel's LGA115x platforms. There are budget chipsets that generally begin with the letter A, B, and H, followed by the series, such as B360 for Intel's 9th-generation Coffee Lake processors, or A520 which is designed for AMD's Ryzen 3000 series and Athlon processors. Going even further into chipsets, there are the more premium variants, such as Intel's latest Z490 chipset for its 10th-generation Comet Lake, and AMD's latest X570 chipset, which generally speaking are both the flagship consumer chipsets for performance and premium features. These models for the most part include certain traits, such as four memory slots with support for dual-channel memory, premium integrated audio, and more t USB support than most users will ever need.

The crème de la crème of motherboard chipsets are the high-end desktop models, or as they are commonly known, HEDT. These chipsets include Intel's X299 and AMD's TRX40, which offer superior memory and connectivity support, and are commonly used by content creators who demand high core-count processors for intensive workloads, such as video rendering, image manipulation, or for just pure E-peen. These typically include support for quad-channel RAM and support for higher capacity memory, and usually include up to eight memory slots, compared to four on even the most high-end consumer-based model.

Choosing the right chipset is important, and it goes hand in hand with CPU selection, as both need to support each other. Some chipsets even include active cooling solutions as they can run very hot, especially AMD's X570 chipset, which generally comes with a cooling fan integrated into the chipset heat sink. When buying a new motherboard, always check which chipset supports which CPU, as installing the wrong processor into the wrong motherboard can not only cause damage during installation, but can effectively kill hardware very quickly if not paired up properly.

THE POWER DELIVERY VRMS AND WHAT THEY DO

In recent years, a lot of focus on selecting a motherboard has been around the power delivery, or VRM as it's commonly known. The term VRM stands for voltage regulation module, and a basic definition of what it does includes controlling the power to the CPU as well, as the system on a chip–or SoC—which is commonly used by processors with integrated graphics. It also converts the power down from the 12V rail on the motherboard—through the 12V ATX power inputs—to a workable DC voltage, as the VRM also acts as a buck, which converts DC to DC power. This conversion is important as it enables the CPU to operate with sustainable

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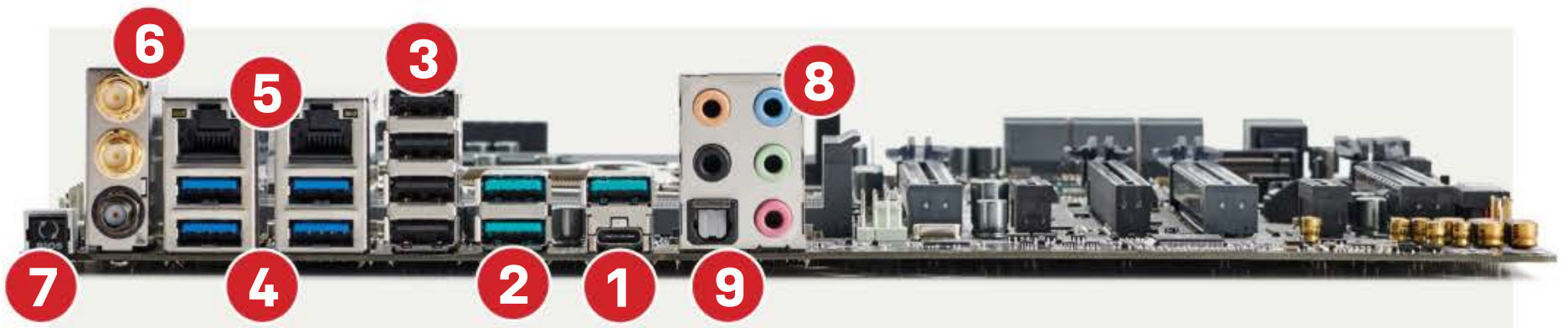

THE REAR PANEL I/O INPUT, OUTPUT, THROUGHPUT

1 USB 3.2/3.1 Type-C
2 USB 3.2/3.1 Type-A
3 USB 2.0 Type-A
4 USB 3.1/3.0 Type-A
5 RJ45/Ethernet
6 Wi-Fi 5/6
7 BIOS flashback button
8 3.5mm audio jack
9 S/PDIF optical output

The rear panel is essentially the input and output section of the motherboard, with plenty of different connector types featured depending on the motherboard itself. The most commonly found connectors include USB, RJ45/Ethernet, and 3.5mm audio jacks. Looking at USB, there are many different types, with motherboard vendors opting to color-code them for easy identification, but this isn't a general rule of thumb. Black ports typically signify basic USB 2.0 ports, with deep blue often associated with USB 3.0 ports. Other colors generally indicate USB 3.2 or USB 3.1 connector types, but as mentioned, this varies on both vendor and model. There are also two types of USB interface found on modern motherboards, including Type-A and Type-C.

The difference between the different standards of USB, including 3.2, 3.1, and 2.0 is in the bandwidth support. USB 3.2 Gen2 typically supports up to 20Gbps or 10Gbps on the Type-C interface, while Type-A will usually support up to 10Gbps. To make it easier to understand, here's the details:

- **USB 3.2 Gen2 x2 Type-C = 20Gbps**
- **USB 3.2 Gen1 Type-C = 10Gbps**
- **USB 3.2 Gen2 Type-A = 10Gbps**
- **USB 3.2 Gen1 Type-A = 5Gbps**
- **USB 2.0 = 480Mbps**

On premium models, motherboard manufacturers add Intel Thunderbolt 3 controllers, which use USB 3.2 Gen2 Type-C connectivity, combined with DisplayPort video inputs to leverage the technology to the full and reap the benefits of enhanced bandwidth.

voltages, which, if it wasn't not converted, would blow the processor pretty much instantly.

A basic example of how a VRM works is as follows. It starts by pulling power from the 12V rail from the power supply into the power delivery or VRM. The VRM then converts this 12V power into a lower voltage so the processor can use it, and it also regulates it so that it stays well within the operating voltage that the CPU requires to work. Even with overclocking the processor, CPU core voltage is typically kept under 1.4V, which in itself is around an 88% reduction in the voltage drawn from the power supply compared to what the CPU is actually using.

Another variable to consider when looking at a motherboard's VRM is its capabilities in relation to maximum supported current. This is especially important when overclocking the processor, as some power deliveries aren't designed for thunderous power loads, although motherboards in recent times are more than well-enough equipped. The configuration of the power delivery is also important, as one of the biggest grumbles is assuming a higher number of power stages or phases mean it has a better VRM. This is a gray area with some vendors in regards to marketing and advertisement, as a six-phase CPU VRM with six 90A power stages can deliver a maximum current of up to 540 amps, where an eight-phase CPU VRM with eight 60A power stages equates to a maximum current of 480 amps.

Some motherboard manufacturers use different types of configuration, with some offering direct phase designs that work in a one-to-one method, with one channel operating one phase from the PWM (pulse-width modulation) controller, which drives and controls the power delivery. Some opt for the use of doublers, which work with two phases operating from one channel. ASUS has switched to "teaming" its phases in pairs, which is designed to deliver higher levels of burst current while maintaining efficiency, in regards to computational and thermal performance.

The benefit of more phases is generally associated with better reliability and can have a positive effect on operating temperatures, as usually the VRM is cooled by a simple heat sink. Some enthusiast-grade models incorporate active designs with small cooling fans, with the most premium including VRM water blocks, such as the ASUS ROG Formula series.

NETWORKING & AUDIO

For networking, some boards use a single RJ45 connector, while others use two for superior connectivity. The general shift in recent months has gone from 1 Gigabit to 2.5 Gigabit Ethernet ports, which motherboard vendors are looking to use, as the new go-to technology as the industry quickly moves far and beyond standard Gigabit. This also includes Wi-Fi, with a big transition occurring this year from Wi-Fi 5 (802.11ac) to the better Wi-Fi 6 (802.11ax) standard. This is good for gamers who demand a solid connection during online gameplay but don't necessarily have the scope or capability to use wired Ethernet, which is almost always the best connection standard for performance and network stability.

Other areas to consider include onboard audio, which usually comes with different inputs and outputs depending on the grade of audio codec that each model is using. More premium codecs, such as the Realtek ALC1220, feature five 3.5mm audio jacks and a single S/PDIF optical output, while lesser codecs like the Realtek ALC892/887 can consist of just three 3.5 mm audio jacks. This is something to factor in when purchasing, or you could use a PCIe lane or USB port and opt for a higher quality audio interface altogether at an additional cost. Some models also include PS/2 ports, which allow the use of older and more legacy peripherals, including keyboards and mice.

PCI EXPRESS X16, X4, X1, AND PCIE 3.0/4.0

The term PCIe stands for PCI Express, with PCI itself abbreviated from peripheral component interconnect, which is an interface standard. This enables users to connect extra components to a system, including graphics cards. This also includes aftermarket sound cards, additional networking controllers, and even RAID cards for storage-savvy power users.

At present, there are two primary interface standards for this type of connector: PCIe 3.0 and PCIe 4.0. The maximum theoretical bandwidth of PCIe 3.0 equates to 32GB/s, with a frequency of 8.0GHz, while PCIe 4.0 doubles these figures to 64GBps and 16.0GHz. The benefits of PCIe 4.0 at the current time are limited, not by the technology itself, but by the shortage of devices that are PCIe 4.0 enabled to make use of this extra bandwidth.

One important point to note is that in multi graphics card configurations, such as AMD CrossFire and Nvidia SLI setups, to run more than one Nvidia GeForce graphics card in SLI, a full-length PCIe 3.0 slot that operates at a minimum of x8 is required, and even some chipsets such as AMD's B550 just don't have the capability to do this. For AMD CrossFire setups, a PCIe 3.0 x4 full-length slot is needed, which is usually operated from the chipset.

In regards to size, PCIe 3.0 and PCIe 4.0 x16, x8, and x4 slots are generally always either full-length or half-length on some models, with x1 slots the smallest of all. The type of slot needed for the type of expansion card usually comes down to what interface the card supports.

The only area that currently shows a real-world benefit comes through storage, and even genuine PCIe 4.0 drives are hard to source. One example is M.2 SSDs with PCIe Gen4 controllers and one of the most commonly used NVMe controllers from Phison, the E16 to be exact. This is identical to the Phison E13 controller bar PCIe 4.0 supports, which does give it an advantage over PCIe 3.0 M.2 SSDs, but not enough to saturate the bandwidth to its fullest capabilities. Phison has announced and previewed its E18 controller based on a 12 nm FFC process, which looks to further enhance the PCIe 4.0 interface.

U.2 may have been quick, but M.2's compatibility proved king in the end.

STORAGE M.2 TO U.2, WITH SOME SATA ON THE SIDE

Storage is an equally important part when considering your new motherboard, whether that's a gaming system, something more for conventional office use, or even a megalithic rendering PC for content creation. For consumer desktop motherboards, there are three main types to consider, which boils down to two things: support from the CPU, and support from the chipset. The SATA or Serial ATA connector has been the standard interface for storage for many years, which is a rectangle-shaped connector that is usually found in two flavors: right-angled and straight-angled format. This is the most commonly used storage interface, with support in regards to RAID arrays dependent on the motherboard chipset used. Intel typically supports RAID 0, 1, 5, and 10 arrays, while AMD only offers support for RAID 0, 1, and 10 officially on its desktop models.

The most common type of premium storage found on motherboards is M.2, with different types, such as the conventional SATA-based M.2 SSDs, or the intergalactic NVMe super-speed drives that operate from PCIe 3.0/4.0 x4/x2 slots. When upgrading a PC, one of the areas where users can see the biggest possible gain in real-world scenarios is going from a SATA 3.5-inch hard drive to a SATA 2.5-inch SSD; the difference in loading times is mind-blowing.

The M.2 interface further improves on this, but with a little bit of diminishing returns due to bandwidth. But in regards to transfer speeds, PCIe 4.0 x4 M.2 drives do it best, with crazy speeds, bearing in mind the limitation is the read and write speeds on the slowest drive in the transfer itself.

Another PCIe-based storage interface is U.2, which is similar to M.2 in many ways and shares similar support for PCIe, meaning more bandwidth and ultimately more performance. The biggest difference between M.2 and U.2—aside from the shape of the connector, U.2 being a square shape and M.2 being small and flat—is that U.2 simply supports higher capacities of SSD, which is typically found on more professional-focused motherboards.

That being said, M.2 drive capacities are starting to increase, and U.2 doesn't seem to have the buzz it once had. The M.2 form factor drives are also considerably cheaper, so it makes selecting one of the many M.2 drives on the market a no-brainer.

NOW YOU'VE MET THE MOTHER(BOARD) WHAT ARE MY OPTIONS?

Despite there being various differences in Intel and AMD's CPU architecture and design, each corresponding socket release yields a new chipset, and thus offers a completely different feature set. The current generation of motherboards include a variety of different characteristics, including USB 3.2 G2 connectivity, with Thunderbolt 3 offering the most comprehensive and exclusive of all the connectors, though this is usually found on more premium models.

Finishing off our little biopic is a table of current motherboard chipsets from Intel and AMD (within the last two years), which CPU architectures are supported, and what market they are aimed at. This journalist regularly overviews chipsets at launch, as well as in-depth

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motherboard reviews over at AnandTech (www.anandtech.com), so for more definitive guides on each chipset, feel free to check them out.

A chipset is not only part of the overall engine, but it's the gateway between the processor and all of the board-integral componentry. One of the most important things to consider when building a new PC or graphics card-laden system is ensuring the processor and the chipset provide adequate features to fit the bill. Leaving the more prosumer chipsets out of the equation. There are notable differences between the HEDT chipsets, such as Intel's X299, and its desktop Z490 chipset. The biggest difference is that both AMD's and Intel's current HEDT platforms support quad-channel memory, while the non-HEDT enthusiast, budget, performance, and mainstream chipsets include support for dual-channel DDR4.

MODERN CHIPSET SPECIFICATIONS

AMD CHIPSETS

	Target Market	CPU Socket	Official CPU Support	PCIe Interface	Memory Channels	Overclocking Support?
TRX40	HEDT/Enthusiast	sTRX4	Threadripper 3000	PCIe 4.0	Quad	Yes
X570	Enthusiast	AM4	Ryzen 3000/2000	PCIe 4.0	Dual	Yes
B550	Budget/Performance	AM4	Ryzen 3000	PCIe 4.0/3.0	Dual	Yes
A520	Budget/Mainstream	AM4	Ryzen 3000	PCIe 3.0	Dual	No
X399	HEDT/Enthusiast	sTR4	Threadripper 2000/1000	PCIe 3.0	Quad	Yes
B450	Budget/Performance	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
X470	Enthusiast	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
B350	Budget	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
X370	Enthusiast	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	Yes
A320	Budget/Mainstream	AM4	Ryzen 3000/2000/1000	PCIe 3.0	Dual	No

INTEL CHIPSETS

	Target Market	CPU Socket	Official CPU Support	PCIe Interface	Memory Channels	Overclocking Support?
X299	HEDT/Enthusiast	LGA 2066	Cascade Lake-X/Skylake-X	PCIe 3.0	Quad	Yes
W480	Workstation/Professional	LGA 1200	Comet Lake/Xeon W-1200	PCIe 3.0	Dual	No
Z490	Enthusiast	LGA 1200	Comet Lake	PCIe 3.0	Dual	Yes
H470	Budget/Mainstream	LGA 1200	Comet Lake	PCIe 3.0	Dual	No
H410	Budget/Mainstream	LGA 1200	Comet Lake	PCIe 3.0	Dual	No
B460	Budget/Performance	LGA 1200	Comet Lake	PCIe 3.0	Dual	No
Z390	Enthusiast	LGA 1151	Coffee Lake	PCIe 3.0	Dual	Yes
Z370	Enthusiast	LGA 1151	Coffee Lake	PCIe 3.0	Dual	Yes
B360	Budget/Performance	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
Q370	Budget/Mainstream	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
H370	Budget/Mainstream	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
H310	Budget/Mainstream	LGA 1151	Coffee Lake	PCIe 3.0	Dual	No
Z270	Enthusiast	LGA 1151	Kaby Lake/Skylake	PCIe 3.0	Dual	Yes

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Create and host your own online website PG. 64
20 TECH FLOPS
The worst tech launches of the century PG. 32
AMD RYZEN 3 3300X
The ideal quad-core CPU for your next PC PG. 64
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TECH PORN

1 MOTHERSHIP CONNECTION

This laptop's thin form factor doesn't stop it from bringing a tonne of ports to the party. We've got Thunderbolt 3, USB-C, USB-A, HDMI, 3.5mm jack, 2.5Gb Ethernet, and an SD card reader. Add super-fast WiFi 6 to the pot and you've got an effective mobile workstation.

2 A THING OF BEAUTY

Let's not beat about the bush here: The 4K touch display on this Blade Pro 17 is absolutely gorgeous. 100 percent sRGB and factory calibration means that colors pop incredibly, while the 120Hz refresh rate lets you kick up your framerates while gaming on that powerful GPU. A slender 6mm bezel of black glass is the perfect finishing touch.

3 NIGHT LIGHT

Every key on the Blade Pro 17's comfortably wide keyboard has its own RGB LED beneath it. With Razer's Chroma software, you can access 16.8 million different colors and a wealth of static and dynamic lightning effects for the keyboard. It looks fantastic in low lighting, along with the brilliantly vibrant screen.

Razer Blade Pro 17 4K

RAZER IS BACK with an update to its long-running and kick-ass Blade laptop line. We've managed to snag the most powerful one on offer: The top-spec model of the Razer Blade Pro 17. This bad boy comes equipped with an RTX 2080 Super and a shiny new Intel Core i7-10875H processor, bringing eight speedy cores to the party. Intel's Turbo Boost can clock those cores up to 5.1GHz for improved performance in CPU-intensive tasks.

A 1TB M.2 SSD means lots of storage and excellent data transfer rates, while 16GB of high-speed memory supports the processor. Both of these can be upgraded: There's a spare M.2 slot for adding a second drive, and the compact motherboard supports up to 64GB of SODIMM RAM. All that hardware is hooked up to a bright and colorful 17-inch 4K touchscreen.

Despite its powerful GPU, this is an impressively slender machine. It weighs barely more than six pounds and is less than 0.78 inches thick, thanks to Razer's vapor chamber cooling design. Heat is spread over a wide surface area inside the casing for improved dissipation, and it clearly works—our Blade Pro 17 barely even got warm.

The casing itself has seen a minor upgrade since the previous model too. It's still cut from a single block of anodized aluminum for scratch resistance and general durability, but the new casing is 25 percent smaller than its predecessor, providing greater portability as well as superior performance. –**CHRISTIAN GUYTON**

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UPDATE THOSE DRIVERS

It's easy to fall behind keeping your hardware up to date. Tools like GeForce Experience are helpful but are also clunky, and motherboard BIOS updates can be a nightmare to manage. Thankfully, these aren't difficult to check; most manufacturer websites make it easy to find and download the latest drivers for your product—it's just up to you to remember to update them once a month!

MAKE – USE – CREATE

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Benchmark your SSD like *Maximum PC*

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CHRISTIAN GUYTON
STAFF WRITER

AT HOME BUT NOT FOLDING

Well, the powers that be are keeping the *Maximum PC* office closed for now, so this is another issue brought to you from the dubious comfort of my GT Omega gaming chair. My apartment is filling up with boxes, and I don't have a dedicated workspace at home like our dear editor.

But even entering month four of lockdown, I'm not discouraged. The good folks at Aukey sent us a gigantic mouse mat that functions well as a hardware testing ground, so that's currently dominating my dining table, along with the liquid-cooled PC you'll see later in the reviews section. I eat dinner on my lap in front of the TV now.

One upside to the lockdown is how much closer it has brought me to the important people in my life. I call my family more regularly now; I get to spend more time with my partner. It's a drastic change from the nine to five, but I'm strangely grateful.

I'd also like to take this opportunity to reiterate something I said last issue; we're looking for black writers to join our body of freelancers, and I'd like to extend that offer to writers from all walks of life and communities too. We want to build *Maximum PC* into a publication with a diverse team of writers, bringing a wider range of experiences to our magazine. We'd love to hear from you!

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IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Atari 2600

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The Atari 2600, with AC adapter and iconic joystick controller. Does the 2600 have a hardwood finish? You are correct!

The motherboard of the 2600 is dominated by an ominous metal box, likely the EMI shield covering the ICs.

This model was revision 13. How lucky!

BACKGROUND

Originally called the Video Computer System (VCS) until 1983, the Atari 2600 was released in 1977. The system was originally released with all six switches on the front of the console, but the console was redesigned in 1980 with only four of the switches on the front, and the other two on the back. The console featured here is a post-1980 model.

MAJOR TECH SPECS

- 1.19MHz eight-bit processor
- 128 bytes RAM
- 192 x 160 pixel resolution
- 128 colors, with max four colors per line
- two-channel mono sound

KEY FINDINGS

- Video game consoles these days may not have a sense of home decor, but some computer companies still believe in the aesthetics of wood paneling. At its release, the 2600 sold for $199. In today's coin, that's $879. In comparison, the launch model of the PlayStation 3 cost only $599. As soon as users figured out that the Atari 2600 could play more games than just *Pong*, the 2600 became massively successful, selling 1 million units in 1979.
- Instead of following the trend of building a limited number of games into the system, the Atari 2600 uses removable cartridges to store games like *Space Invaders*, *Pac-Man* and *Pitfall*. Each player can select the difficulty of the game they're playing by simply flipping a switch from "A" to "B". Which one was harder is anyone's guess.
- There are four screws holding the upper and lower case together. These screws in the back are at an odd angle: Almost 30 degrees off of vertical. Strange. With a design that is unseen in just about any other electronic device, the motherboard is propped up and sits at an angle of 30 degrees inside the Atari. Now those case screws make sense! And finally, cables that are not soldered to the board! The RCA cable is easily removed.
- The motherboard easily lifts out. The only things securing it down were the angled screws we removed from the outer case. The case of the 2600 is 2.6 times larger than the motherboard. The motherboard is dominated by an ominous metal box, likely the EMI shield. A few short twists with pliers and the shield lifts free; Atari gets a +1 on repairability for not soldering the shield to the motherboard. The back of the Atari 2600 motherboard has nothing interesting on it, except a great appreciation for through-hole soldering and hand-drawn circuits.
- The Atari 2600 stores games in read-only memory chips housed in external cartridges. This allows for a potentially infinite number of playable games for the console. Atari's custom chip, the Television Interface Adapter (TIA) is the moneymaker of the 2600, as it enables multiple colors, increased graphic capabilities, and sound. Because memory was so expensive during the 2600's design, the video processor has no external RAM. As a result the CPU must send video data to the TIA one line of video at a time.
- We give the Atari 2600 a big plus for repairability. Every component is attached via through-hole solder, so replacing a burnt-out resistor or IC is quite feasible. However, parts are now almost impossible to get hold of.

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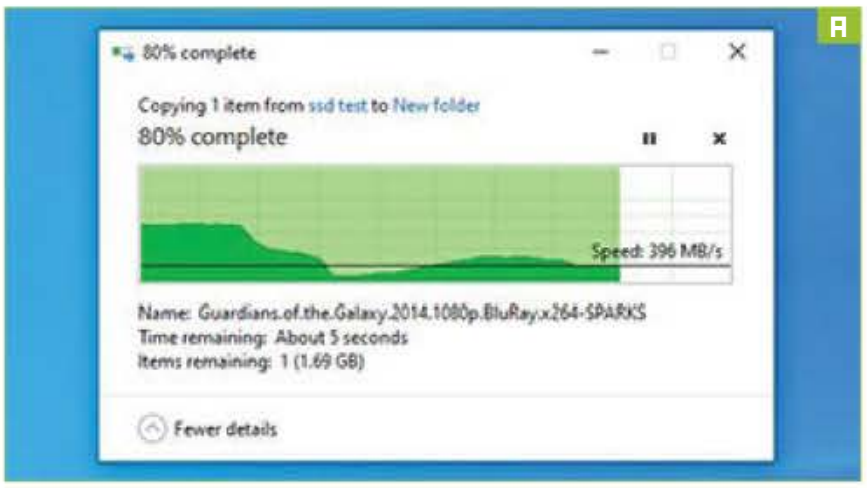
Beyond that, around 30GB of mixed files, ideally from a game install, is required.

SURELY THE MOST MERCURIAL of PC components, solid-state drives have long presented a moving target when it comes to benchmarking. Early SSDs were all about headline transfer speeds. Then it became apparent that performance fell off rapidly as the drive's capacity was used. As solid-state technology matured, random access to small data sets emerged as a more relevant measure of real-world performance. But even now, the best test regimes can't fully capture the character of an SSD. After all, there's no substitute for hammering a drive with day-to-day storage for years.

However, it is possible to capture a pretty good idea of the performance of a drive in relatively short order using freely available software. Our approach involves testing both peak throughput and arguably more relevant 4K performance, along with an added real-world element in terms of file transfers and prepping the drive for testing. The latter involves filling the drive entirely before running benchmarks. That can be quite time-consuming with very large drives, in which case you can opt to skip it. Where practical, and especially with a brand-new drive, however, it can help to make benchmarking more realistic as well as shake out any serious flaws in sustained performance. –JEREMY LAIRD



1 INITIAL SETUP

To mimic our benchmarking, the target SSD should be a secondary rather than primary OS drive. However, results don't vary hugely when testing an SSD as the main system drive.

›› We typically test box-fresh SSDs, so a critical part of our regime is to first fill the drive to the brim and then delete all the data and format the volume. It's an easy way to make sure that a drive's basic garbage collection routines are functional. For an SSD that's already heavily used, this is probably redundant.

›› It doesn't really matter what kind of data you use for the pre-test fill. We favor large files like high-resolution video for simplicity. While you're filling the drive, keep an eye on the Windows Explorer progress graph—it will show the transfer rate. Should the drive's performance dip or stall due to exhausting any cache [**Image A**] or the controller chipset overheating, you'll get a feel for how long that takes in terms of time or data quantity.

2 PEAK SEQUENTIAL THROUGHPUT

To measure peak performance we use CrystalDiskMark 6. It's the tool we use for testing sequential read and write performance. It's worth noting that this type of benchmark typically shows the drive off at its best. The quantity of data transferred is limited and won't exhaust features like high-speed caches, which can mask the underlying performance of the flash memory used in a drive.

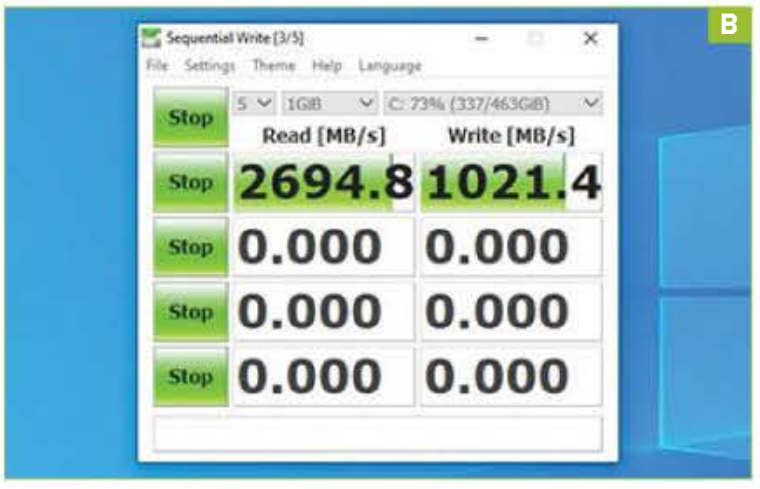
›› CrystalDiskMark uses incompressible data in default mode, so it won't throw out overly optimistic results as a consequence of the clever compression algorithms that often can't be used with real-world data sets. Also, for SATA drives, sequential performance is often limited by the interface. In practice, you won't see much more than 550MB/s in either direction.

›› Once downloaded, fire up CrystalDiskMark and select the correct drive in the drop-down menu. Then hit the "Seq Q32T1" button [**Image B**] and let it rip. Results in CrystalDiskMark should be close to the peak sequential performance claimed by your drive manufacturer. If not, you may have a faulty drive or a setup issue.

3 RANDOM ACCESS PERFORMANCE

Peak sequential performance involves the biggest numbers. But when it comes to that all-important subjective sense of snappiness and response, peak throughput is largely irrelevant. Instead, measuring random access performance provides more insight.

›› The standard test in this context is usually known as 4K random reads and writes. "4K" refers to the file size, and "random" to the idea that the files will be written to or read from multiple locations on the drive, in a process that mimics typical OS and application drive traffic.



© ANVIL, CRYSTALDISKMARK 6

» A further layer of distinction involves queue depth. That's a metric of the number of parallel storage requests or threads in operation at any one time. In a desktop context, a typical application will generate a single thread, requesting a read or a write, waiting for the result, then following with another. Server systems often support multiple applications or clients and operate with queue depths of 32 or more. But for desktop PCs, queue depths in the range of one to four are more realistic. IOPS or IO operations is another measure of the same performance.

4 ANVIL'S STORAGE UTILITIES

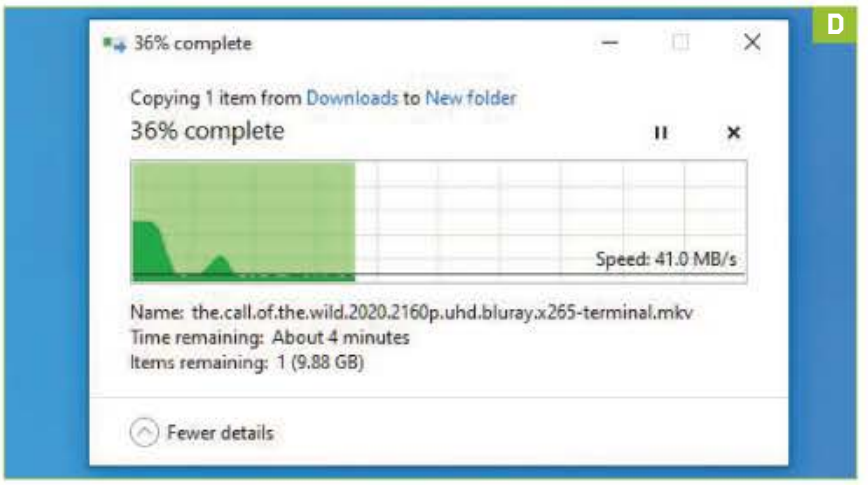
Our weapon of choice for measuring 4K random performance is Anvil's Storage Utilities, as it allows for tests at the queue depths most relevant to desktop computing.

» Download Anvil version 1.1.0, fire it up and then select "Benchmarks" from the top menu. Choose "Threaded IO / write." At the top of the pop-up window is a slider, with a selection of queue depths. Choose queue depth one, then hit "Start" below. Note the result in MB/s, then repeat the process at QD2 and then QD 4.

» Next, go through the same process with reads [**Image C**], selecting "Benchmarks" and then "Threaded IO / read," before once again testing performance at QD1, QD2, and QD4. You should find that QD1 is a worst-case scenario, with performance increasing as you increase the queue depth. Inevitably, most drive manufacturers quote 4K random or IOPS performance at QD32. That's a best-case scenario that isn't hugely relevant to desktop as opposed to server applications. Consequently, we focus our testing on shorter queue depths.

5 FILE TRANSFER

When it comes to emulating our SSD test routine, the trickiest element is our 30GB internal file copy. The idea is to provide a real-world snapshot of sustained performance and uncover any glaring limitations that can occur, such as the cache limitations and chipset overheating.



© MICROSOFT

» For our testing, we use a 30GB tranche of game files, chosen for a mix of large and small file sizes. For obvious copyright reasons, we can't share the precise files we use. However, select 30GB of mixed files from any modern game installation and you will have something that's reasonably similar, albeit not accurate enough for direct comparisons of performance.

» The test routine is straightforward. It's conducted internally on the drive to exclude the influence of a secondary drive. First, copy your test files to the target drive. Then create a new folder on that same drive and paste a new copy of those files into the folder. Record the time it takes to complete the copy. Again, it's worth keeping an eye on the Windows Explorer progress graph [**Image D**] to look for any obvious drops in performance.

6 COMPARING PERFORMANCE DRIVES

So, you've installed the software and run the numbers. But what does it all mean? As we implied earlier, much depends on the type of SSD in hand. SATA-based drives don't just have the peak sequential limitations mentioned earlier. They're also compromised by the AHCI protocol, which was originally conceived for mechanical drives with magnetic platters.

» Newer M.2 drives benefit from both the PCI Express interface for improved peak bandwidth, and the NVMe protocol, which was expressly optimized for use with modern solid-state storage tech. For quad-lane M.2 drives operating on the PCIe 3.0 standard, maximum theoretical read and write speeds are in the region of 4GB/s, with real-world performance topping out at around 3.5GB/s. For the latest PCIe 4.0 drives, you can double that to 8GB/s as a maximum theoretical, with early drives hitting around 5GB/s in practice. As for 4K performance, that's more of a leveller, with few drives of any type scoring above 200MB/s at QD1.

SSD SETUP

To extract accurate benchmark numbers from any SSD, you need the right configuration and motherboard settings. For the most part, this isn't complicated, and default motherboard settings will typically be optimal. But that's not always the case. There are a few basics to be aware of. What's more, if you have a range of BIOS tweaks, you may not wish to lose them with a global rollback to default.

First, refer to your motherboard's documentation to ensure that you have the drive connected to the optimal slot or socket. With many motherboards, overall bandwidth is shared between M.2 and SATA resources, so not all M.2 slots or SATA ports are equal. Depending on how you populate them, you may not be able to access a given drive's full performance.

With that ticked off, double-check your BIOS settings. For a SATA drive, ensure you are running in AHCI mode. For a quad-lane M.2 drive, make sure that PCIe x4 is enabled where available. Just remember, on some motherboards selecting x4 mode for an M.2 slot can force a pair of SATA ports (typically ports five and six) to be disabled, again because bandwidth is shared across storage interfaces.

Post To Your WordPress Blog

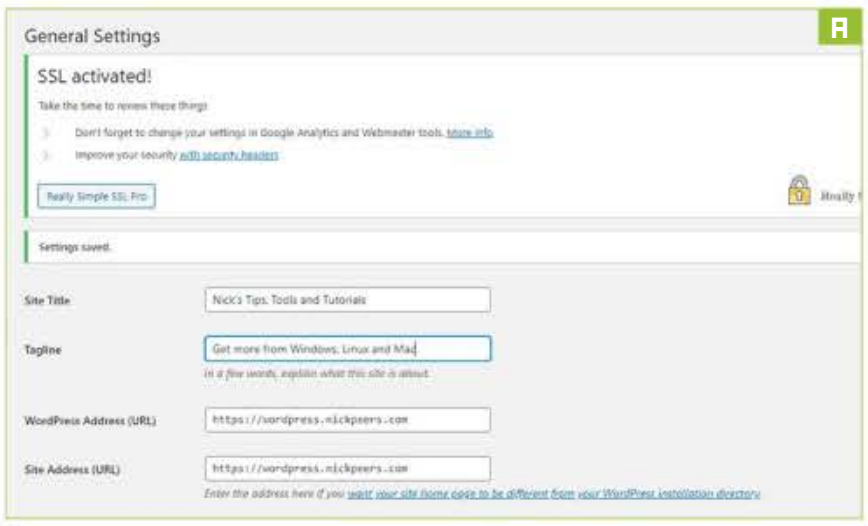
YOU'LL NEED THIS

WORDPRESS SERVER
Any reputable web host will do, or you can host it yourself on your own server.

LAST ISSUE WE REVEALED how to set up and secure your new WordPress website. Now it's time to start using your new site's tools to produce the content you'll be showcasing to others. Content on WordPress consists of two basic types: Posts and pages.

Posts are primarily the stuff of blog posts: Time-sensitive material like an ongoing diary, where everything is published in a single feed and is date and time-stamped, with the most recent post at the top. Posts can be assigned categories and tags, to enable your readers to create their own filtered feed based on specific topics or areas of interest.

Pages are for static content with no expiry date: There's no publish date attached, and they're useful for providing information, such as an "About" page. You can't assign tags or categories to pages; instead, you organize them in a hierarchical fashion, using a parent-child hierarchy. One page is the parent-for example, "About"—and then you create child pages off this, such as "Contact," "Biography," "FAQ," and so on. These are then allocated an order in which they appear in the hierarchy—typically via a drop-down menu that's always visible. **–NICK PEERS**



A

1 SET UP BASIC SITE INFO

Log into your WordPress installation and head to "Settings → General." Enter your site title and provide a tagline—these will be displayed on your site [**Image A**]. You can also change the administrator email from here if you wish. Once done, scroll down and click "Save Changes."

›› Your site's overall appearance is determined by its theme—we'll be looking at this in more detail next issue (including how to customize it)—but for now if you visit "Appearance → Themes" you'll see that several have been preinstalled with your WordPress install. Select one and click "Live Preview" to see how it looks, then click "Activate" to switch to that theme if it's a better fit for your site's content.

2 YOUR FIRST POST

Click "Posts" in the left-hand menu to access the "Posts" screen. Here, a list of all posts—published or in draft form—can be found. You may see a dummy post ("Hello world!|) that has already been published—roll your mouse over it to reveal options to edit, quick edit, delete, or view. Click "Trash" to remove it. Now click "Add New" to start a new post using WordPress's Block Editor.

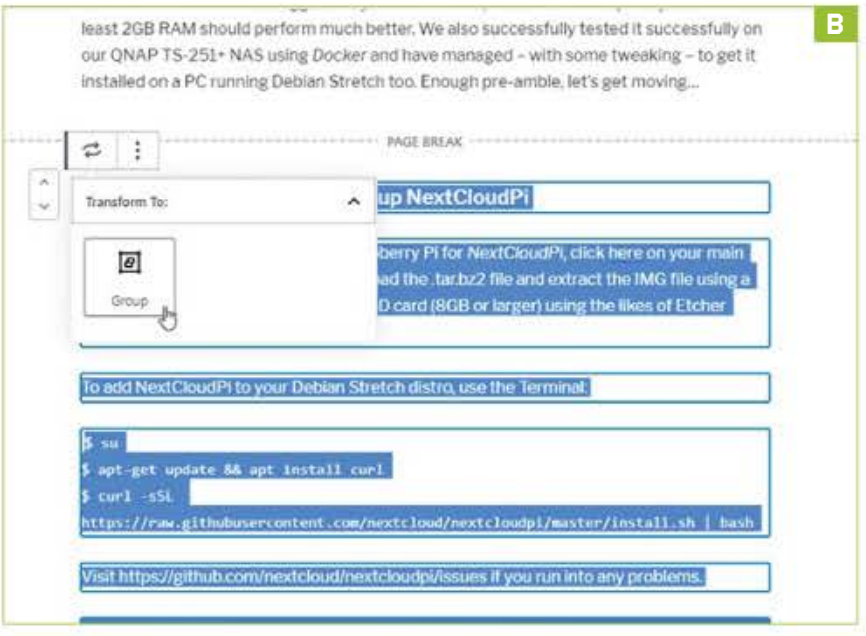
›› A quick orientation guide reveals how the new editor works: That content is arranged into individual blocks, with different types (text, image, and video) offering their own set of formatting controls depending on the type of content you've selected.

›› Each post has its own title, so start by clicking inside the "Add title" box to add it. Next, click inside the "Start writing or type / to choose a block" box to enter your first paragraph of text.

3 FORMATTING TEXT

Text is entered into "Paragraph" blocks. They're called this because each individual paragraph resides inside its own block—when you hit Return, a new text block will be created underneath the preceding one. When these are selected, you will see tools on the left of the block that enable you to rearrange their order, either using the up and down arrow keys to move between adjacent blocks, or by clicking and dragging the middle button to move to a completely different part of your post.

›› Formatting controls can be found in two places: A formatting bar above the current paragraph provides commonly used tools, while on the right of the page you'll see a sidebar with two tabs—"Document" and "Block." The "Block" tab provides even more formatting options, including the ability to vary the size of your text and to insert a drop cap.


least 2GB RAM should perform much better. We also successfully tested it successfully on our QNAP TS-251+ NAS using Docker and have managed - with some tweaking - to get it installed on a PC running Debian Stretch too. Enough pre-amble, let's get moving...
PAGE BREAK
Transform To:
Group
up NextCloudPi
berry Pi for NextCloudPi, click here on your main
ad the .tar.bz2 file and extract the IMG file using a
D card (8GB or larger) using the likes of Etcher
To add NextCloudPi to your Debian Stretch distro, use the Terminal.
$ su
$ apt-get update && apt install curl
$ curl -sSL
https://raw.githubusercontent.com/nextcloud/nextcloudpi/master/install.sh | bash
Visit https://github.com/nextcloud/nextcloudpi/issues if you run into any problems.
B

© WORDPRESS

4 INSERTING IMAGES

When you want to insert an image, create a new block beneath the currently selected one by clicking the "+" button next to the WordPress logo. Choose "Image" from the pop-up menu that appears to create an image block. Click "Upload" to upload a file from your computer.

›› The image will be uploaded to your media library, allowing you to use it elsewhere on your site too. To aid you in finding it in the future, take the time to provide a title and description. Once done, click "Select."

›› The image will appear at your cursor point. To flow the following paragraph's text around the image, click the "Change alignment" button and choose "Align left" or "Align right," depending on where you want the image to sit.

5 ADD MORE PAGE ELEMENTS

WordPress supports all kinds of useful page elements. Some, like "Heading," "List," and "Quote" are self-explanatory. "Page break" enables you to insert a page break between two existing blocks—a handy way to break up lengthy posts. Where the break occurs your readers will see a "Pages: 1 2 3 4" prompt to jump to different parts of the post (or page).

›› Gallery enables you to select a group of photos and display them as a simple multi-columned gallery—use the "Block" sidebar to set the number of columns, and the images will automatically reflow to suit.

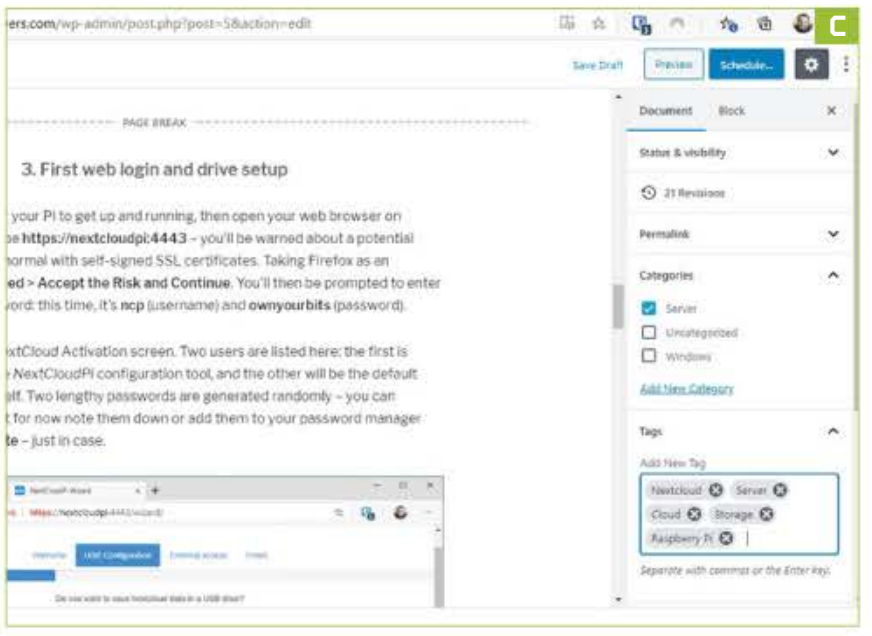
›› You'll also see a "Group" option, which allows you to select multiple blocks and group them as one, making it easy to move them together. To do this, select all your blocks, and you'll see the group icon appear above them —click this followed by "Group" to transform them into a group [**Image B**].

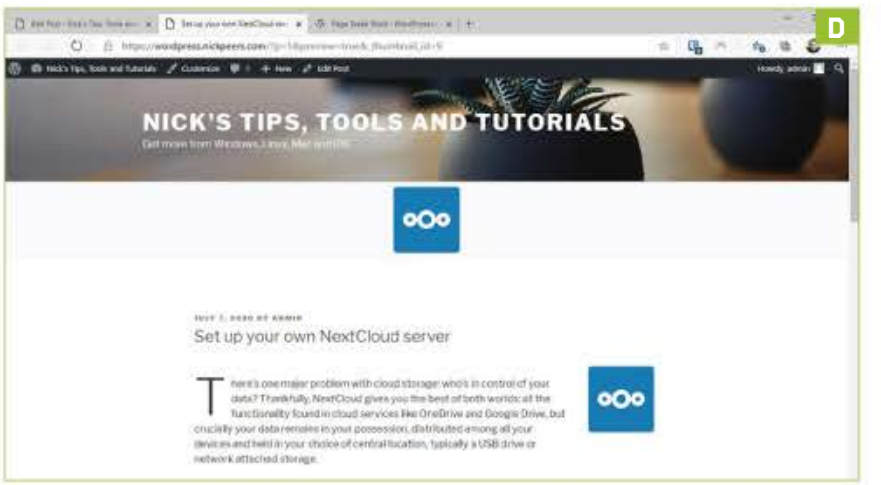
›› You'll still be able to edit each individual block; to select the blocks as a group again, use the "Block Navigation" tool that's at the top of the page. Another handy use for blocks is to duplicate similar layouts—all you then need to do is swap out the old content for the new.

6 PUBLISH YOUR POST

Keep clicking "Save Draft" to periodically update your post. Click "Preview" to open a preview in a separate tab—you can leave this open, and when you next click "Save Draft" the preview will update accordingly.

›› Once you're happy with your post, hold off clicking the blue "Publish..." button . First, switch to the "Document" tab on the sidebar [**Image C**]. Here you'll see options to set the post's visibility (choose private or password-protected to restrict who can see it), and change the publish date to schedule a post to be published at a specific point in the future. Ignore the post format option for now—more on that next issue.





NEXT ISSUE: ADVANCED TIPS AND TECHNIQUES.

›› You'll also see a link to compare different saved versions of your document, enabling you to roll back to an earlier version should you ever need to. Beneath this are options for creating a "permalink" (a convenient URL to share with others), plus assign the post to a category and add tags. These can help your readers to find posts, and once you create them, they'll appear here with convenient checkboxes so you can easily add them in future. Tags and categories can also be managed via the main WordPress dashboard—click the "W" icon in the top-left corner to return here after saving or publishing your post.

You can set a "featured image"—this appears above your post and accompanies it in the main feed [**Image D**]. Finally, use the "Discussion" section to disable comments and pingbacks. Once done, click "Publish" (or "Schedule" if you've set a future publishing date).

BACK UP YOUR WORD-PRESS INSTALLATION

You've secured your WordPress website, but you still need to protect yourself against data loss. If you're hosting your own site, or your provider doesn't provide automatic backups, you'll need to take matters into your own hands.

A WordPress backup consists of two elements: All the files on your web server, of course, plus the underlying SQL database that powers your installation. You can back these up manually using a combination of FTP and phpMyAdmin, but a simpler—and more sensible—solution is to make use of a free plugin.

Most backup plugins come in free and paid-for versions—the free versions will back up everything to your own web space (so you'll need to download this manually), but reserve some options, such as backing up to the cloud, for their paid-for licenses. One plugin that offers several free remote backup sources—including Dropbox, Amazon S3, FTP, and Google Drive—is UpdraftPlus.

Install it via "Plugins → Add New," then click "Activate," and UpdraftPlus will guide you through taking your first back-up—be sure to click "Settings" when prompted to connect to your chosen backup destination, and set an automatic backup schedule for your files and database. Now you can sit back and relax—your WordPress site is being backed up on a regular basis.

Spice Up Your Taskbar With TaskbarX

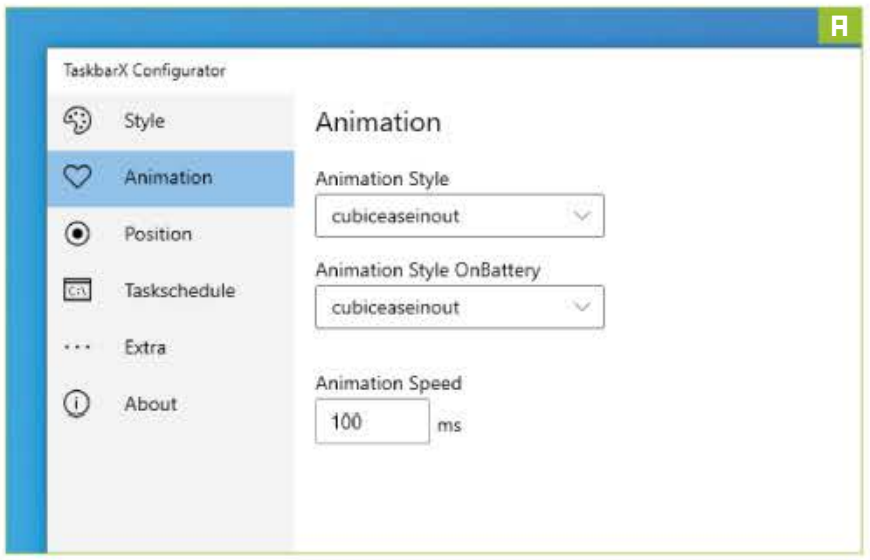
YOU'LL NEED THIS

TASKBARX
https://chrisandriessen.nl/taskbarx

WINDOWS 10

THE WINDOWS 10 TASKBAR may not be the most exciting thing in the world, but you can give it a healthy dose of visual flair with the help of TaskbarX, an app that makes it easy to center your taskbar icons—and a whole lot more. It works particularly well if you want to have a cleaner, more understated look for your taskbar. Centering your icons with TaskbarX gives a more modern look than the default Windows taskbar appearance, especially if you only have a couple of pinned icons.

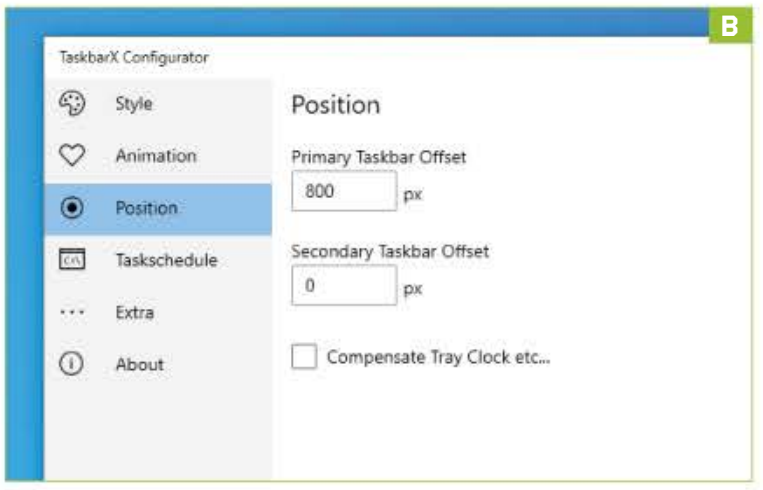
You can take things further with some of TaskbarX's built-in options. For example, you can make your taskbar entirely transparent, making your icons appear to be floating against your wallpaper. You can change how your icons animate into position when you open a new app. And it works well if your setup involves multiple monitors, with lots of extra options to customize it exactly how you want. We will take you through the process of giving your taskbar some much-needed love and attention with this handy little program. **–ALEX BLAKE**



1 GET STARTED

TaskbarX comes in two flavors: A free version hosted on the developer's website, and a version on the Microsoft Store that carries a small fee. Both of these versions are functionally the same, however.

›› Head to chrisandriessen.nl/taskbarx and click "Download Zip," then extract the zip archive to your chosen location. TaskbarX is a portable app and does not have an installer, so double-click the TaskbarX.exe file to run it—you will notice that any icons pinned to your taskbar have now become centered. By default, TaskbarX will now run every time you load your PC. If you want to adjust any of TaskbarX's settings, you need to launch the TaskbarX Configurator.exe file located in the same folder.



2 EXPRESS YOUR STYLE

Once you have opened TaskbarX Configurator, you will see several tabs on the left-hand side of the app, starting with "Style." This lets you choose what visual appearance your taskbar will have. The first selection is "Default"—this keeps the taskbar opacity the same as if you were not using TaskbarX.

›› "Transparent" makes your taskbar entirely transparent. "Blur" adds a heavy blur to your wallpaper behind the taskbar while maintaining low opacity. "Acrylic," meanwhile, attempts to replicate the trappings of Microsoft's Fluent Design System. The result is similar to Blur's clouded taskbar, but it opts for a higher opacity level, meaning the edge of the taskbar is easier to see.

›› After choosing, click "Apply" to make the changes.

COMBINING TASKBARX AND WINDOWS SETTINGS

The visual tricks of TaskbarX can be combined with Windows 10's taskbar settings for some interesting effects. Open the Windows 10 Settings app, click "Personalization," then click "Taskbar" at the bottom of the left-hand column. Under the "Combine taskbar buttons" header, select "Never" in the drop-down menu to see your icons expand to show window titles as well as icons. Alternatively, enable the "Use small taskbar buttons" setting to save space while still retaining a centered taskbar.

Experiment with different settings here to see what kind of effects you can create using both Windows 10 and TaskbarX. The app is very flexible and accommodates a wide range of Windows 10 settings adjustments. Some changes to Windows 10's taskbar settings may require you to refresh TaskbarX—just click the "Restart TaskbarX" button at the bottom of the Configurator app to see your changes take effect.

© MICROSOFT, TASKBARX

3 ANIMATION EFFECTS

Next, click "Animation" in the left-hand toolbar. Whenever you open a new app (and its icon appears on the taskbar), TaskbarX will re-center the taskbar icons to take it into account. The app gives you a vast number of options when deciding what sort of animation to use—there are over 30 animations to choose from [**Image A**]. To see one in action, select it, then click "Apply;" TaskbarX will refresh, and your taskbar icons will re-center themselves using the chosen animation. Alternatively, open a new app to see its icon appear in the taskbar using your chosen animation effect.

›› You can select a different animation (or none at all) if your PC is running on battery power as opposed to being plugged in. This is useful if you want to save on tasks that might add extra load to your processor (such as animations) and eat into your battery life.

›› Finally, you can also change the animation speed in milliseconds. Some animations run very quickly at the default 100ms, so increasing this number can be a way to see the animation in more detail.

4 TAKE UP A POSITION

With TaskbarX running, your taskbar icons will be centered. You can make some slight adjustments to this, but there is no "left-align" or "right-align" option in the Configurator app. So, what do you do if you want to achieve a similar effect?

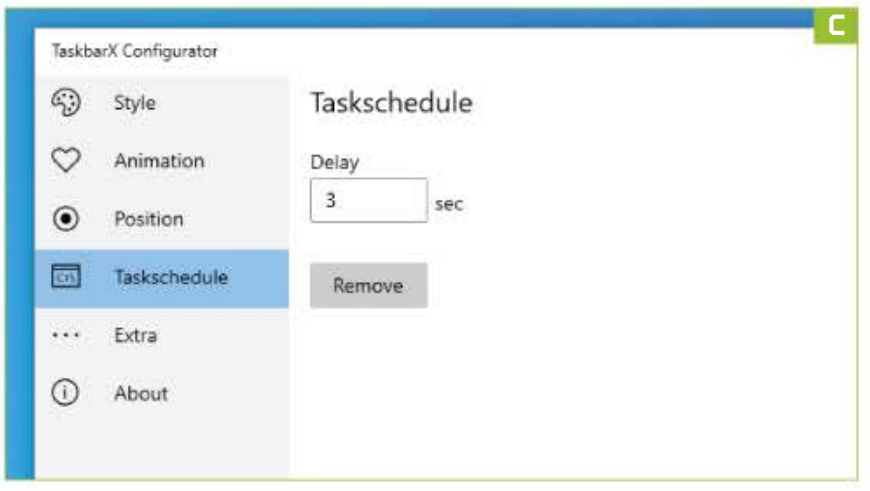
›› Well, you can offset your icons. If you want to right-align your icons, enter a large number in the "Primary Taskbar Offset" window. The required number will depend on your monitor's resolution: On a 1440p display, for example, around 800px is enough to right-align the icons [**Image B**]. To left-align the icons, on the other hand, just enter a negative number, such as -500.

›› When determining how to center your taskbar icons, TaskbarX measures the distance between the left-hand edge and right-hand edge of your display. However, this does not consider the Windows search box on the left and the notification area on the right, and you may feel that your icons look off-center because of this. To take these into account, tick the "Compensate Tray Clock" checkbox and click "Apply." The center of your display will now be calculated using the right-most edge of the search box and the left-most edge of the notification area.

5 TASKSCHEDULE

When you first log in to Windows 10, a lot of processes start up at once. If you are concerned that TaskbarX could conflict with some of these, or load prematurely—for example, before Windows Explorer has loaded the taskbar—you can delay it from launching immediately using the "Taskschedule" tab.

›› This is set to use a three-second delay by default [**Image C**]. You can increase this if you like, or remove it entirely if you think there are unlikely to be any issues with it running straight away. We recommend you leave it at three seconds, though, just to be safe.



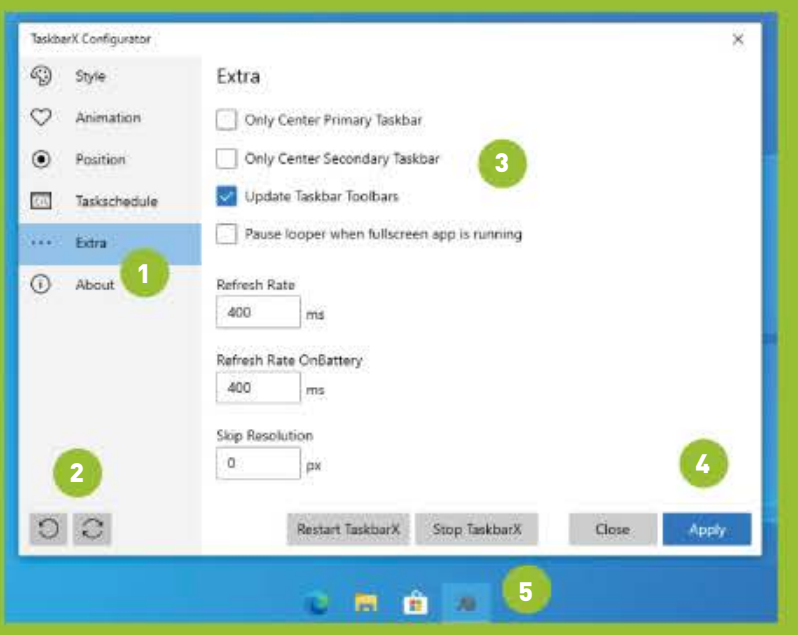
6 EXTRA OPTIONS

There is much more that TaskbarX can do, with plenty of additional settings that can be found in the "Extra" tab. For instance, if you have added toolbars to your taskbar—such as showing addresses or links—then the "Update Taskbar Toolbars" option will reposition your icons accordingly. If you are using multiple monitors, you can also choose whether the taskbar is centered only on your main monitor or only on your secondary monitor.

›› Further down in the "Extra" tab you can find a few more options. TaskbarX refreshes regularly to detect changes (such as when you add a toolbar), and this refresh rate is set to 400ms. You can adjust this—lowering the number will result in TaskbarX updating more quickly but adds a bit more load to your processor. You can set different refresh times depending on whether you are using battery power, too.

›› And finally, you can also tell TaskbarX to stop centering your icons and to put them back on the left-hand side if your monitor's resolution width is set to a certain number.

TASKBARX IN ACTION



1. CATEGORIZED SETTINGS
TaskbarX's settings are divided into various categories, all of which you can access from this tab.

2. RELOAD AND RESET
Sometimes you need to refresh the app's settings. The left button here resets all settings to default, while the right button reloads the current settings.

3. DETAILED SETTINGS
The settings for each category can be accessed and tweaked in the right-hand panel.

4. APPLY YOUR CHANGES
Make sure to click "Apply" once you have made some changes to ensure that TaskbarX implements them.

5. YOUR MODIFIED TASKBAR
You can see TaskbarX's changes on your Windows 10 taskbar. Here, we have chosen to make our taskbar transparent, alongside the default centering position for the icons.

BUILD IT

ZAK STOREY, EDITOR

Black and Red

We're getting back to the basics with this classic sub-$1200 gaming PC

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

WITH AMD'S RYZEN 3300X FINALLY LANDING on our shores, we just knew we had to throw it into a full-on system build to get the most out of it, and its accompanying new chipset, B550. It's not every day that AMD launches a brand-new budget chipset quite like this series, and certainly not with such fanfare, so we decided to put together a little budget(ish) build to see exactly what we could get out of this fledgling quad-core, eight-thread processor.

So yes, at its heart we have the Ryzen 3 3300X processor. Compared to today's many-threaded monsters littering the consumer ecosphere, a quad-core processor certainly does look small-fry in comparison, especially as we've already had the 3200G from AMD as well. However, there's some significant differences between the 3300X and its iGPU cousins that are well worth mentioning. First and foremost, it is in fact based on the Zen 2 7nm architecture, unlike the iGPU variants that are secretly 2nd-gen Ryzen in disguise on 12nm. Additionally, it features the full complement of 24 PCIe lanes (16 for graphics, four for the DMI, and four for a direct M.2 SSD interconnect), unlike the iGPUs, which only have half the number of graphics lanes. Thirdly, and perhaps more importantly, it also comes with support for PCIe 4.0 straight out of the gate. The only downside? No integrated graphics of course. Oh and then there's the price—$127. Yup, Go back three years, and to get something similar you'd be paying near three times the cost.

So the question is: Is this the new affordability king of the gaming ecosystem? Time to find out.

AUDIO READY

WHAT A TIME TO BE ALIVE, and what a challenge it is to get system parts in, that's for sure. Our regular press contacts are struggling to get inventory across the sea for us to build with, and as such it has been near-impossible for us to get exactly the right GPU that we wanted. We're actually running a Gigabyte GeForce RTX 2070 Gaming 8G in this build, but sadly there aren't any available across the US right now. However, you can pick up a Gigabyte GeForce RTX 2070 8GB Windforce 2X, with an identical clock speed, cooling, and power-delivery solution for just $400, albeit it has slightly tweaked visuals compared to the card we are using here.

Aside from our frustratingly annoying GPU situation, we've gone with one Asus's latest B550-F Gaming motherboards, which is surprisingly expensive for a B550 board, at $210, although more on that later. We've paired that with 16GB (2x8GB) of Corsair Vengeance LPX DDR4 memory at 3600 MHz, one of be quiet!'s latest Pure Rock 2 Black CPU coolers, a 1TB Intel 665P M.2 PCIe 3.0 SSD, a Corsair 110R chassis, and a fully modular Fractal Design Ion+ 760W PSU as well, to round out our build price at $1,183.

So overall it's not too expensive, and not ridiculously cheap either, but it should have more than enough going for it to crush frame rates at 1440p and below. Let's take a look at how to put this back-to-basics beast together...

INGREDIENTS

PART		STREET PRICE
Case	Corsair Carbide 110R	$70
Motherboard	Asus ROG Strix Gaming B550-F Gaming	$210
CPU	AMD Ryzen 3 3300X	$127
GPU	Gigabyte GeForce RTX 2070 8GB Windforce 2X	$400
Memory	16GB (2x8GB) Corsair Vengeance LPX DDR4 @ 3600	$70
PSU	760W Fractal Design Ion+ 760p 80+ Platinum	$122
Storage	1TB Intel 665P M.2 PCIe 3.0 SSD	$115
CPU Cooler	be quiet! Pure Rock 2 Black	$45
OS	Windows 10 Home 64-bit OEM	$24
Total		$1,183

1 THE NEW RETRO?

WE'VE FINALLY reached the precipice folks! Here you see Corsair's latest Carbide 110R budget chassis. Clocking in at $70, it's definitely on the budget-end of the spectrum, but that hasn't stopped the Californian company from pushing what it can fit into this thing to the absolute limit. There's a fantastic full-sized PSU cover, intelligent cable routing, a fully tempered-glass panel, good support for AIO solutions, and perhaps most impressivly of all, a 5.25-inch disk drive compartment.

It's been a long time since we've seen a chassis with a disk drive; in our age of digital streaming and beyond, it's a device that's seemingly been relegated to the history books. Many who still use them push the device to an external USB dock instead. Nonetheless, its interior looks mighty fine, and with a pseudo brushed-aluminum finish on the plastic front panel, it's pretty classy too.

2 STRIP DOWN

AS USUAL, THE FIRST THING we recommend you do with any new build is strip down the case as far as you can go. Hiding away any outward-facing panels in the chassis box will ensure they don't get scratched during the building process, and will make your brand-new rig all the easier to build in, as it'll give you more clearance, and be lighter in the process. We've also gone and removed the hard-drive caddy here too, as we know we won't be using any drives in this build, and it gives us a bit more room to play with when installing the PSU. A quick peek around the back and you'll find slots for 2x 2.5-inch drives, and plenty of cable management.

3 FAN REALIGNMENT

WHY CHASSIS MANUFACTURERS still do this on budget cases is beyond us, but we've gone ahead and moved that exhaust fan from the rear of the chassis to the front. This helps us draw cool air in through the front, through the dust-filtered meshes, and push the air back to the CPU fan and the graphics card.

Simply unscrew the fan screws. Move the fan to the front of the chassis, and then resecure where you see fit. We'd recommend that if you only have the one fan, you mount it somewhere in the middle between where your GPU and CPU are located to give each a bit of cool air.

4 MOTHERBOARDS APLENTY

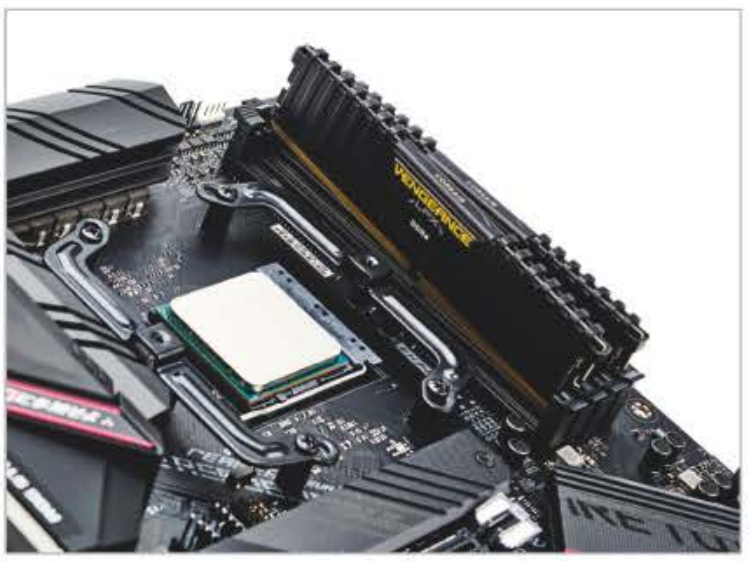
AND HERE WE HAVE our first B550 sample in, the Asus ROG Strix B550-F Gaming WiFi. At $210 it's a bit of a confusing offer. There's no denying that it looks good: The integrated I/O plate is nice, the design aesthetic is classy, and there's plenty of storage connectivity on offer here, but it's somewhat confusing as to why it's this darn expensive. For instance, at the same price you could get the ASRock X570 Steel Legend, Gigabyte X570 Aorus Elite WiFi, or the MSI MPG X570 Gaming Edge WiFi.

One thing to note with B550 boards as well is that if you're looking to use these with a PCIe 4.0 M.2 storage solution, only the top-most M.2 slot is PCIe 4.0 enabled.

7 MEMORY MOUNTING

WITH THAT OUT OF THE WAY, next up is the memory. Our 16GB kit comes as two separate 8GB sticks. You'll want to install these in the correct channel, so always refer to your motherboard manual to be sure. Typically, however, they want to be spaced apart from one another, in alternate slots. With the B550, lift the tabs at the top of the memory slot, then align the stick with the bump in the slot and the notch in the stick, and carefully push it into place until you hear the tab click back into position.

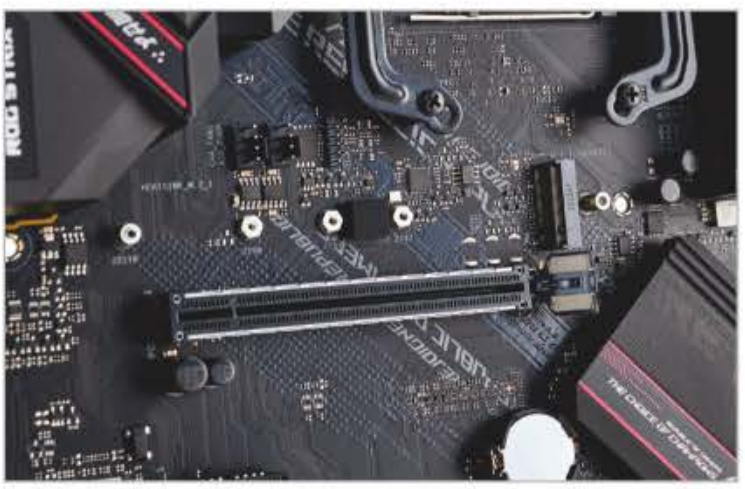
One thing you don't want to do is to try and force the stick into position in the incorrect orientation, as you could damage the memory stick or the motherboard.



8 M.2 INSTALLATION

FOR OUR STORAGE we're going with a single M.2 PCIe 3.0 drive in the form of Intel's 665P. It's 1TB of pure kick-ass storage, at a crazy affordable price, and an iterative update on its 660P predecessor. To install it, remove the top-most M.2 heatsink from the motherboard. Simply remove the two screws holding it in place and lift up.

To install the M.2, notice the notch cut out of the drive, and then carefully line it up with the notch in the slot. This is there to ensure you place the drive so that the SSD controller is facing up and can be cooled passively via chassis airflow or an active heatsink, like we have in our build. To reinstall the heatsink, remember to remove the plastic film from the thermal pads, then place the heatsink back down, and resecure with its two screws.



5 RETENTION PLATE INSTALLATION

INSTALLING THE RETENTION BRACKET for the be quiet! Pure Rock 2 couldn't be easier: Simply remove the two plastic brackets that come as standard with the motherboard, place the be quiet! stand-offs over them, align the two AMD mounting brackets in the correct orientation, and then secure them down with the included screws.

One of the big advantages with AMD's Ryzen platform in general is that you don't need any proprietary backplates with your cooling solution, as most cooling manufacturers have adapted their mounting mechanisms to work with the bracket that comes as standard with the motherboard itself.

6 RYZEN CPU INSTALLATION

ONCE THE MOUNTING BRACKETS are in place for the Pure Rock 2 Black, it's time to crank it up a notch and install the CPU into its socket. For any Ryzen processor, simply lift up the retention arm in the socket. Note the gold triangle on the corner of the CPU and the triangle cutout in the socket, carefully place the processor into position, making sure that the pins fit into the slot, then lower the retention arm back into place. This will lock the Ryzen CPU into position, and we're good to go.

9 COOLER INSTALLED

NOW THAT'S OUT OF THE WAY it's time to install the CPU tower. The Pure Rock 2 has a fantastically simple mechanism to install it onto the bracket we added earlier. Simply place a dot of thermal paste down onto the CPU, then carefully place the heatsink down onto the chip, with the small metal bracket, slotted over the top of the contact block of the cooler. Once it's nice and snug on the contact plate, use the two included screws to tighten the tower down onto the bracket. Make sure you tighten them a little bit at a time on either side, so that you don't over-tighten one and put unwanted pressure on one side of the CPU. Now that's done, we can get the whole unit into the case itself.

10 MOTHERBOARD IN

WE'RE FINALLY STARTING to see this build come together. Installing the motherboard here is simple. Just line up the integrated rear I/O plate with the back of the chassis, place the motherboard down into position over the required stand-offs, and screw it into place with the screws found in the case accessories box that was included in the hard-drive caddy.

You're looking for a hexagonal screw head to use here, although you'll know if you use the wrong screw as it won't secure and will fall out. In a pinch, and if you know your system's not going to be moving about very often, you can just secure the four corners and a middle point. Don't worry about securing every single stand-off—if you can't reach one it's not the end of the world.

11 POWER SUPPLY IN

NOW IT'S TIME for the power supply. The Fractal Design Ion 760p is a fully modular 80+ platinum power supply and more than enough for what we'll need for this build. In fact we're only expecting it to pull 284W from the wall under load. But if we do decide to upgrade in the future, and add more drives, more cores, and more graphics performance, we've got that extra headroom available if we need it. Additionally, although theoretically not the most efficient way of running a PSU, using less than 50% of the power supply's maximum rated wattage ensures that the PSU fan won't spin up, and in turn reduces overall system noise during load and when idle.

Install the necessary cables, then slot the PSU in via the back of the case, and secure with the same thumb screws that were used for the motherboard.

12 CABLES IN

WITH THE POWER SUPPLY IN, simply route the cables through the rubber grommets and install them into the motherboard. We don't have the graphics card in right now, but it's advisable to slot the PCIe power through the cable hole in the PSU cover—that way you're good to go as soon as the GPU is installed.

It's also a good time to install any fan headers or front I/O ports that might be needed. If you're looking for a cleaner build and aren't worried about connectivity, you can get away with connecting just the front power button if you so desire. That keeps cables out of the way, and makes it look far cleaner.

13 CPU FAN INSTALLATION

NOW TO GET THAT CPU tower fan in. This attaches via rather frustrating little metal brackets. Attach one of them to the two mounting holes on either side, and then pull them back and stretch them over the heatsink until they're in the middle. It's very fiddly and frustrating, and if you remove them repeatedly they can warp irreparably, to the point where the fan will fall off perpetually. Fortunately be quiet! does include a spare pair, so if it does happen you've got another set to swap out. Or you can mount an additional 120mm to the back of the tower.

In the past we've used two fans at the same time, and cable-tied them together between the two sets of metal clips. It works well to keep them on the tower.

Once the fan is in position, tie the cable up into a little loop, and then install it in the CPU fan header.

14 GPU IN

THE LAST PIECE of the puzzle is the graphics card. Simply remove the two PCIe slot covers in the rear of the chassis that correspond to where the graphics card is going to be installed. Slot it into position, and then use the two screws from the covers to resecure it in place. Once that's out of the way, install the PCIe power cables to the GPU.

Then it's just a case of tidying up the back of the chassis, resecuring all the panels, and installing your favorite operating system, and you're good to go.

1 **Installing a fan into the rear of the case is one of the first things we'd change. That way we'd have an airflow system running completely through from the front, through the CPU tower and out the rear of the chassis.**

2 **We've not installed the GPU power cable in through the PSU cover cable passthrough, due to the size of the graphics card and the port locations, instead opting to go through the large cutout at the front. This looks a bit cleaner, in a more vertical orientation.**

3 **Surprisingly for such a budget-oriented case, the Carbide 110R actually has a tonne of cable management space at the top of the chassis.**

4 **We're not expecting the Ryzen 3 3300X CPU to get that hot, but if it does we have the option of adding another fan to this heatsink tower.**

STEALTH MODE ENGAGED

AND THERE YOU HAVE IT, one crisp, clean Ryzen 3 3300X build complete. And what does it look like? A dark box. That's a very underwhelming gaming PC. The only thing that has a speck of RGB is the graphics card, and even that's negligible.

But boy doesn't that look clean. Okay, so the first thing we'd change is to add an LED strip inside, preferably one that we could just hook up to a SATA connector and call it a day—a 12-inch white LED strip. BitFenix sell a magnetic one for just under $13 from Newegg, and it'll add a tonne of light to the interior for very little outlay, and hopefully pierce through that smoked window.

So how was the building experience? Honestly, a cake-walk. Figuring out exactly how the Pure Rock 2's bracket was meant to be installed to the AMD backplate took a few minutes, but other than that everything was easy. The motherboard went in seamlessly, there was plenty of space for cable management, the case panels popped off nice and easy too—it was a pleasant experience. The only downside was the lack of included fans. That would be one of the first things we'd change—even swapping out that front one for two or three 120mm Corsair MLs or Noctuas would make a big difference to system temperatures.

It's also, as far as cases go, perhaps a little too subtle for our taste. Even square boxes need a bit of flair, and the Carbide 110R hasn't committed one way or the other. It's not a sharp, square NZXT box, nor is it a curved, elegant Phanteks, or a cooky Fractal. It's got a very 2010 vibe to it, and it feels like it's missing a bit of extravagance.

As for performance, overall it did really well. The Ryzen 3 3300X might not be the fastest chip in AMD's arsenal, but for price to performance it hits the nail on the head for mid-range gaming. In Cinebench we saw a multi-threaded score of 1,123, and its single core prowess tapped out at 198, which is impressive for such a budget processor.

Gaming did fall a little flatter than we'd have liked compared to the zero-point, but then that's to be expected, as more titles are taking advantage of more cores, and the GPU in that build is none other than Nvidia's improved RTX 2070 Super.

The biggest hit this build took was in the storage department. Although it's a relatively quick drive compared to a standard SSD, the 665P just doesn't keep up with the Corsair Force MP600 found in our zero-point. But then you are only paying $115 for 1TB of PCIe storage space. Yes, QLC isn't the best flash memory, neither in flat performance or long-term endurance, but for the price it's hard to knock.

Ultimately our stealthy killer PC is perfect for those on a budget looking to cut their teeth in the world of 1440p gaming.

BENCHMARKS

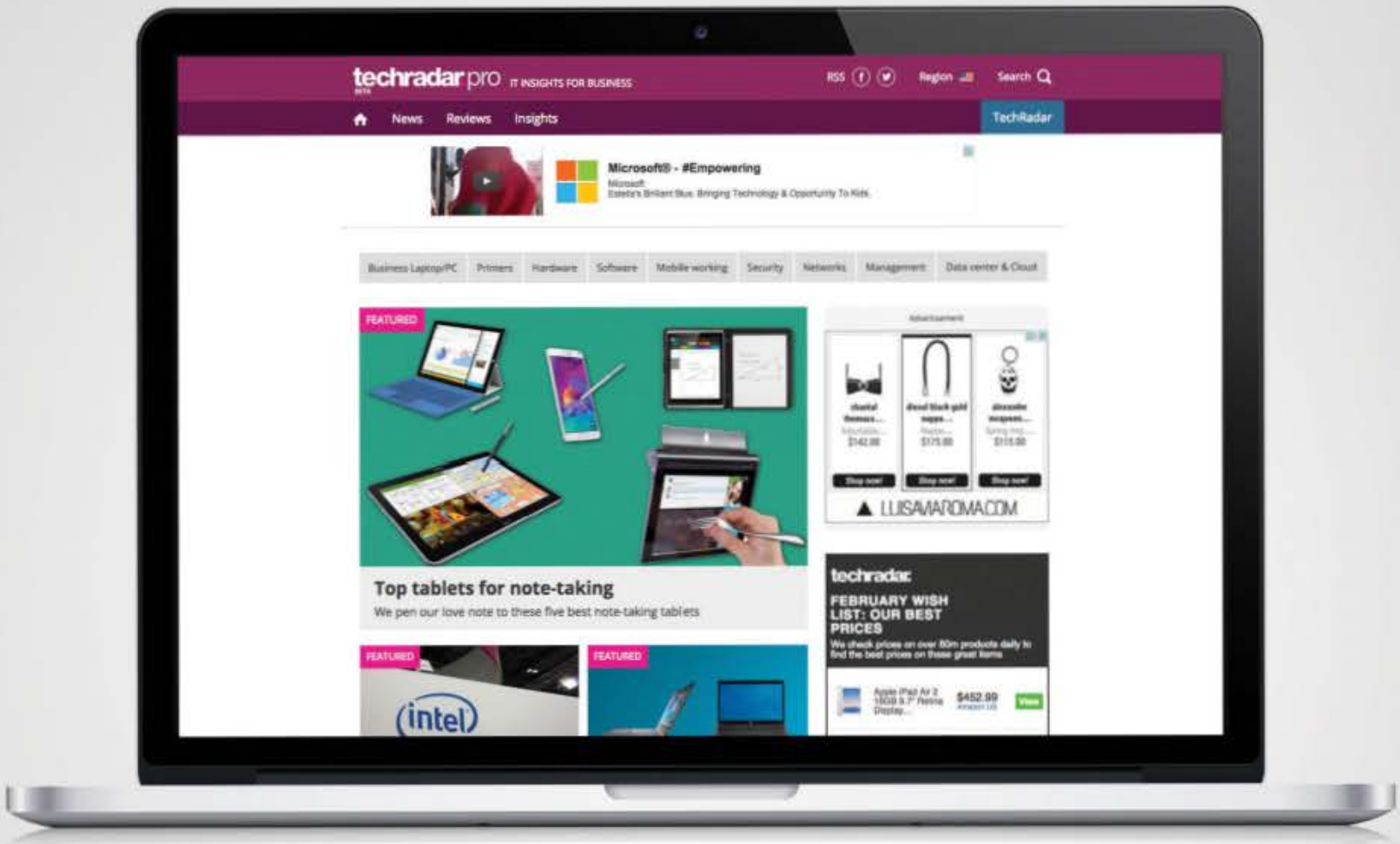
	ZERO-POINT	
Cinebench R15 Multi (Index)	1,630	1,123 (-31%)
CrystalDisk QD32 Sequential Read (MB/s)	4,918	1,975 (-60%)
CrystalDisk QD32 Sequential Write (MB/s)	2,746	1,763 (-36%)
Middle Earth: Shadow of War (fps)	83	77 (-7%)
Total War: Warhammer II (fps)	71	66 (-7%)
Assassins Creed Odyssey (fps)	51	47 (-8%)
3DMark: Fire Strike (Index)	21,586	18,532 (-14%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 5 3600X, 32GB of G.Skill Trident Z DDR4 @ 3600, an Nvidia GeForce RTX 2070 Super, and a 500GB Corsair Force MP600 M.2 PCIe 4.0 SSD. All tests were performed at 1440p at the highest graphical profile.

techradar.pro

IT INSIGHTS FOR BUSINESS



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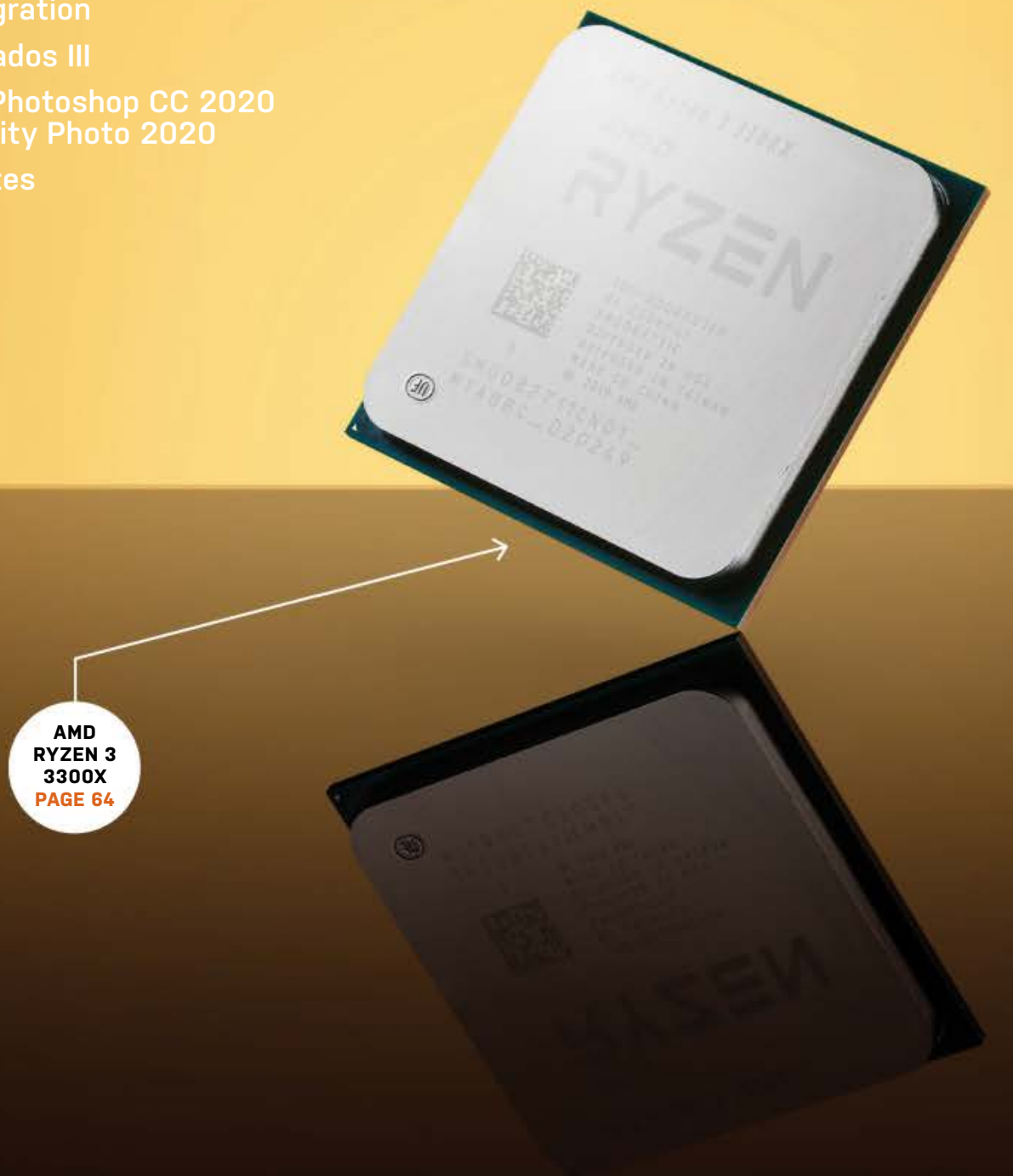


AMD Ryzen 3 3300X

The Goldilocks chip

$127 FOR A QUAD-CORE, eight-threaded processor, complete with a hefty 18MB of cache, a fairly typical Ryzen clock knocking in at 4.3 GHz at max, and of course access to all the juicy connectivity options bundled in with the X570 and B550 chipsets: There's a lot to love when it comes to the Ryzen 3 3300X. For not a lot of cash, it offers a tempting solution for those looking to upgrade their ageing rigs, or set up a brand new one.

We always enjoy looking back at the past with processors, as it gives us a good idea as to what the future might hold, and just how far we've come in such a short time. And with the Ryzen 3 3300X, it's absolutely no exception. Back in the days of Kaby Lake, a quad-core processor with multi-threading as standard would set you back close to $300, albeit with a slightly higher clock speed. Fast forward three years and that price has halved, and you've gained a bevy of connectivity solutions with it. There's a lot to love here. But this is 12 months on from the initial 3rd-gen Ryzen launch, and we've seen Ryzen 3s before, so why is it so interesting? And why now?

Well in short, the Ryzen 5 3400G, Ryzen 3 3200G, and the Ryzen 3 3100G aren't technically 3rd-generation Ryzen parts. They're in the product stack, sure, launched at the same time as the original 3rd gen, but the reality is these iGPU cousins were meagre imitators, harboring that pesky 12nm+ Zen architecture we saw with the launch of AMD's 2nd gen. These chips lacked PCIe 4.0 support, and perhaps worst of all only came with eight PCIe 3.0 graphics lanes direct to the CPU itself (the other eight being reserved for the onboard iGPU).

These were processors designed with the HTPC, esports and home-server markets in mind, where more often than not those PCIe lanes would be taken up with RAID cards or audio solutions instead of graphics. For AMD, the solution was simple for anyone serious about gaming on a budget—get a Ryzen 5 3600. But this left a gaping hole in the market, one Intel happily filled with its high-performing Core i5s and i3s, all of which featured the full-fat 16 PCIe 3.0 lanes and strong single-core performance. Fast forward a year and at last we see a competitor, in the form of this fruitful Ryzen 3 3300X, in all of its 7nm glory.

So then, is it any good? Well the long and the short of it is, yes, darn good in fact. In Cinebench R15, we saw this thing clock in an impressive 199 points in the single-core tests, and 1,123 points in multi-core. Throw it into gaming, and it pulls off some impressive performance at 1440p, clocking in 72fps in *Total War: Warhammer II* with an Nvidia GeForce GTX 1080, and 53fps in *Ghost Recon: Wildlands*. Not too shabby. It does lose some points compared to the likes of its older sibling, the Ryzen 5 3600X, but that's only in heavier multi-threaded titles. Interestingly, we saw temps remain resiliently the same between the two chips, both floating around the 66 C mark under load regardless of core count. This is likely due to the fact the 3300X is still utilizing the same number of core complexes as the 3600X, albeit with two additional cores disabled within those CCXs.

AMD's Ryzen 3300X is an interesting, perhaps somewhat late addition to its arsenal. It represents an intriguing proposition for those looking to upgrade their ageing quad-core platforms, with access to newer connection standards and more modern motherboards at an affordable price. But we have to question whether it's just too little too late. AMD has confirmed its 4th-generation chips will be with us before the year is out. So investing in a processor that's likely going to drop in price within the space of the next few months seems somewhat foolhardy. Nonetheless, right now it's a fantastic processor, and ideal for those looking for something for either home office use, or to use in a slim, lightweight gaming machine. **–ZAK STOREY**

BENCHMARKS

	AMD Ryzen 3 3300X	AMD Ryzen 5 3600X
Cinebench R15 Single (Index)	**199**	198
Cinebench R15 Multi (Index)	1,123	**1,659**
Tech ARP's X264 (avg fps)	27.32	**33.08**
Fry Render (m:s)	02:13	**1:55**
Power Draw Idle/Load (W)	**54 / 185**	58 / 232
Total War: Warhammer II @ 1080p (fps)	72	**76**
Ghost Recon Wildlands (fps)	53	**55**
Maximum Overclock (GHz@V)	**4.2 @ 1.35V**	4.2 @ 1.4V

Best scores in bold. Our test bed consists of an Asus ROG Crosshair VIII Formula, 32GB of G.Skill Trident Z Neo, and an Nvidia GeForce GTX 1080. All games were tested at 1080p on the highest graphical profile, with average fps noted.

VERDICT **9**

AMD Ryzen 3 3300X

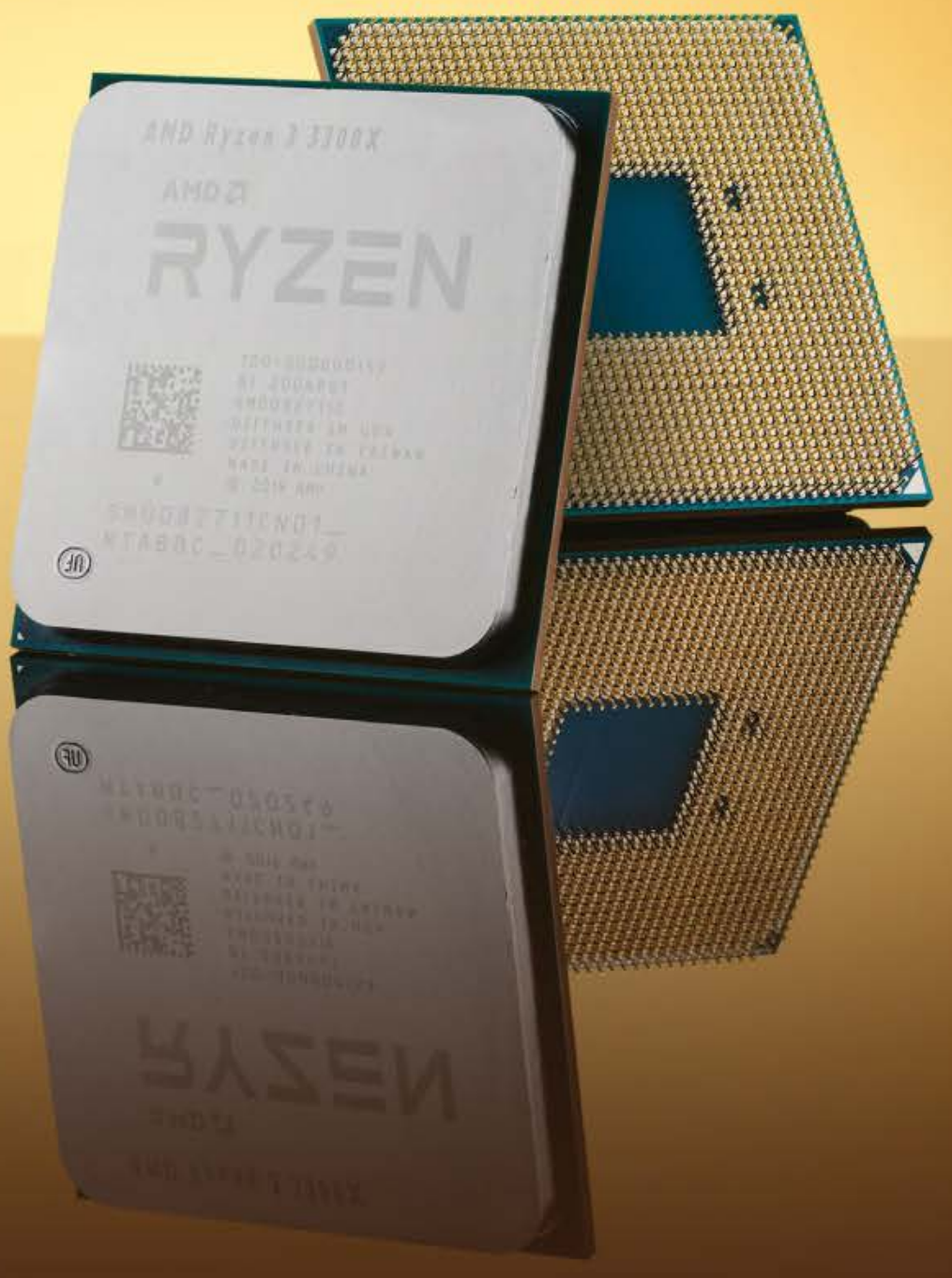
+ THE EARLY BIRD Strong single-core performance; incredible price; good affordability; strong feature set.

– FASHIONABLY LATE Next-gen chips are right around the corner; as hot as a 3600X six-core.

$127 www.amd.com

SPECIFICATIONS

Cores / Threads	4 / 8
Base / Turbo Clock	3.8 / 4.3 GHz
Architecture	Zen 2
Lithography	TSMC 7nm FinFET
Memory Support	Dual-channel 3200 MHz
PCIe Support	x16(+4) PCIe 4.0
Integrated Graphics	N/A
TDP	65 W



When it's not about the professional end, is four cores enough?

EK Fluid Gaming 270 Vanquish

What's cooler than being cool?

BUILDING A CUSTOM liquid loop yourself is hard. Why do that work yourself, when you could pay someone far more experienced to build it for you? While we here at *Maximum PC* will always advocate for building systems with your own hands, it's hard to argue against the level of professionalism on display in the EK Fluid Gaming range.

We're looking at the Fluid Gaming 270 Vanquish, the "mid-range" offering from EK's pre-built gaming series—although calling this $2,900 beast mid-range is laughable. The 270 Vanquish rocks an RTX 2080 Super for graphics, and an eight-core, 16-thread Ryzen 7 3800X processor, backed up by 32GB of high-speed memory from HyperX.

So, it's a powerhouse machine. All of EK's systems are capable gaming maxhines, and this one is no exception. As you can see from our benchmarks, the 270 Vanquish can handle the latest games in 4K, although more demanding titles might be better off at 1440p. We'd expect as much for a system that costs this amount, but the main draw here is that sweet, sweet liquid-cooling loop.

This is EK's own design and parts, collectively called the EK Hardline loop. EK-HD tubes and fittings connect to high-end RGB-lit water blocks for the CPU and GPU, fed not by a conventional tower reservoir but a sleek distribution plate at the front of the case. Heat dissipation is handled by a 360mm EK-Alustream radiator with three RGB fans. The plate is also illuminated by an LED strip, which looks great when filled with clear coolant.

The setup process is relatively straightforward. A large bottle of Cryofuel coolant comes included, along with a tubed bottle to easily fill the distribution plate. It's not exactly plug-and-play, since completely filling the system requires restarting and cycling multiple times before it's ready to use, but it comes with a simple step-by-step guide and only requires the standard Windows 10 setup once you've got it running. It does need more TLC than an average air-cooled system, but topping up and cycling the coolant is easy enough.

Despite the powerful components, front-mounted pump, and multiple fans, the Vanquish isn't a particularly noisy machine, perhaps a feature that can be accredited to the stylish Lian Li case. Even during stress tests, the CPU temperature never rose above 50 C, while a spot of regular gaming barely saw it scrape 35 C. That liquid loop clearly does the job.

CPU performance is strong, but this is a gaming system, and the graphics card is the main attraction here. The RTX Super line has some of the best performance GPUs available right now, and the 2080 Super is an excellent choice for this machine. A slightly cheaper RTX 2070 Super version of the Vanquish is also available, and might appeal to those who don't have a 4K monitor (or don't quite have $3K to drop on a gaming PC).

Let's break that $2,900 down for a moment, and consider the value proposition at play here. We did a bit of online browsing, and we reckon that any dedicated builder could assemble a system just like this—sans the custom cooling loop—for around $2,300. That leaves us with $600 going solely on cooling (and the knowledge that your system will be perfectly built with no effort on your part).

It might sound like a lot to dedicate to system cooling, especially given that the Ryzen 7 3800X comes with a free stock cooler, but the breakdown actually fits. The RGB water block for the GPU alone is worth over $100. If you're looking to build a high-end liquid-cooled system, buying a pre-built model from EK will barely cost you more than buying the components new and assembling the system yourself.

So, the EK Fluid Gaming 270 Vanquish is a stunning gaming PC with absolutely top-notch cooling and dazzling aesthetics to boot, and we can't recommend it enough. 3TB of high-speed SSD storage and a sweet three-year product warranty are simply icing on the cake. Just please negotiate among yourselves to determine who gets to buy one; if they sell too many pre-built machines, we might find ourselves out of a job! –**CHRISTIAN GUYTON**

VERDICT
9
KICK ASS!

EK Fluid Gaming 270 Vanquish

VANQUISHER Great all-round performance; looks incredible; good value for money.

VANQUISHED Still expensive; requires some regular maintenance; heavy as hell.

$2,900, ekfluidgaming.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	2,195 (1%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	3,565 (14%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	2,494 (17%)
3DMark: Fire Strike Ultra (Index)	6,988	7,147 (2%)
Total War: Warhammer II (fps)	42	50 (19%)
Tom Clancy's The Division 2 (fps)	38	46 (21%)
Metro Exodus (fps)	37	44 (19%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an an Intel Core i9-7900X, 32GB G.Skill RipJaws V series DDR4 @ 3,000, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile. *Metro Exodus* tested at 4K at High.

SPECIFICATIONS

Processor	AMD Ryzen 7 3800X
Graphics	Nvidia GeForce RTX 2080 Super
RAM	32GB (4 x 8GB) HyperX Fury DDR4 @ 3,200MT/s
Motherboard	Asus Prime X570 Pro
Primary Storage	1TB Samsung 970 EVO NVMe M.2 SSD
Additional Storage	2TB Seagate BarraCuda HDD
Cooling Solution	EK Hardline Custom Water Loop
PSU	EVGA 650W 80+ Gold
Case	Lian Li PC-0011D Black
Warranty	Three years

The 270 Vanquish looks incredible when it's fully illuminated.

There's nothing quite like a 35-inch panel to make life that little bit easier.

ViewSonic Elite XG350R-C

The perfect home office gaming monitor?

IN THIS WONDERFUL world of working from home, finding the right monitor to maximize your productivity is pivotal. You can have the best system on the planet, but if you're still staring at a 22-inch screen from 2009, it might be about time you ditched the aging tech, and boosted your monitor real-estate to something a little more modern, and with quite a lot more breadth.

We're big supporters of ultra-wide and multi-screen setups here at *Maximum PC*, and have had a lot of hands-on time with the 21:9 form factor as a result. We've tested everything from the very budget-oriented panels from the likes of Acer, AOC, and MSI, to the absolute high-end Asus ProArt screens and LG's fantastic 38-inch panels.

So why do we recommend it? Well simply put it allows you to do so much more than what you can on a traditional 24-inch or 27-inch 16:9 monitor. For many the idea of two screens makes a lot of sense—twin 27-inch monitors can easily help you separate multiple documents, programs and tasks, and allows you to game on a single screen if you so desire. It's affordable because you can take an older screen and pair it with a newer one. The only problems lie with the fact that they take up a lot of desk space, and there's that thick bezel in between the two panels, no matter what you do.

You can get 54-inch screens these days, effectively merging those two 27-inchers, but the reality is that's still a massive display to have on your desk. 34 inches on the other hand seems to be the middle-child of the productivity monitors right now, and the sweet spot, if you're looking for something both to game on and spend your working hours with.

IN THE SWEET SPOT

Take this ViewSonic Elite XG350R-C as an example. It's slightly larger than your standard superwide, coming in at a 35-inch diagonal. But it also comes with a high-contrast 2500:1 curved (1800R) MVA panel that's perfect for vibrant color work; a 100Hz refresh rate for buttery smooth desktop and gaming usage; a crisp 1440p resolution, giving you the same pixel density as the best 1440p 27.5-inch monitor; and FreeSync (and therefore G-Sync) as standard—all for an incredibly impressive $660. That's a lot of screen for not a huge amount of outlay. So what's the catch?

Well honestly not a lot. Colors are crisp and accurate, and the contrast is fantastic as a whole. It does theoretically support an HDR mode, but we found it quite dull, and there doesn't seem to be an expanded color gamut, which makes you question why that HDR10 spec was included at all. Although you won't be missing out on much, as HDR on PC is still somewhat underdeveloped. On the whole the stand and ergonomics are fairly clean. The Elite branding isn't too obtuse, and what little RGB lighting there is you typically forget exists after about 5-10 minutes of use. The only thing we would say is the bezel is rather thick. You've got a big half-inch plastic border running around the entirety of the panel itself, which detracts from the aesthetic appeal.

We're starting to see a lot of these prices drop for this form factor too. In fact, you can pick up a fairly similar screen from the likes of Asus for about $80 less, although the color accuracy doesn't quite match what you'll find here. ViewSonic has a nack for producing precision-perfect panels, and the XG350R is no exception to that. Despite the fact it's branded as a gaming monitor by design, when it's side by side with a $1,000 Asus ProArt 34-inch screen the difference is very difficult to perceive. **–ZAK STOREY**

VERDICT **9**

Viewsonic XG350R-C

ILLUMINATING Pristine color accuracy; great price point; hyper-versatile.

FADED HDR a bit pointless; thick bezel.

$660 www.viewsonic.com

SPECIFICATIONS

Resolution	3440 x 1440
Pixel Density	107 PPI
Panel Type	35-inch 8-bit VA
Maximum Refresh	100 Hz
Contrast	2500:1
Response	3 ms G2G
Display Inputs	DisplayPort, HDMI
VESA Mount	100 x 100
Warranty	3 Years

SteelSeries Apex 3

A competent, affordable keyboard for membrane fans

THIS IS THE BLACK SHEEP of SteelSeries's Apex line, a lone membrane keyboard in a collection of mechanical offerings. It is by far the cheapest Apex keyboard, costing just 50 bucks (every other Apex keyboard costs upwards of $100), and it's easy to see why: This is the toned-down version of the Apex chassis, a simplified model that forgoes per-key illumination and the little OLED smart display that defines its fellow keyboards.

That's not to say that the Apex 3 isn't a great product. This sensibly priced keyboard definitely still has the build quality of the pricier Apex keyboards, with a sturdy polymer casing and durable keycaps. It comes with a snap-on magnetic wrist rest with a matte, rubberized surface, and includes the same metal scroll wheel and button for quick media controls. This doesn't feel remotely flimsy; it's a weighty, well-constructed product.

The substitutes are generally acceptable alternatives for a cheaper product. Instead of fully addressable RGB lighting on every key, the translucent plastic panel beneath the keys is broken into 10 bright lighting zones. If all the aesthetics you want are a gently shifting rainbow pattern or solid color, then the Apex 3 is perfectly capable of that. While the diminutive OLED multimedia control display that defines the Apex line is missing from this model, we don't really notice its absence, since the physical media controls are still present.

One change that the Apex 3 does lose points on is its new key switches. While the more expensive Apex keyboards solely use mechanical switches with a variety of switch types, the Apex 3 uses SteelSeries's "Whisper Quiet" membrane keys. These switches are true to their name, producing very little noise even compared to similar membrane keyboards. Even fast touch-typing is quiet. If you're planning on using your computer in a shared environment, it could be ideal.

However, these keys are somewhat squishy when pressed, lacking the satisfying physical feedback of SteelSeries's other mechanical keyboards. Using a membrane keyboard also means you don't have totally independent N-key rollover, so there's a limit to the number of keypresses that can be simultaneously processed. While it's comfortable enough to type with, the Apex 3 certainly doesn't provide the snappy sensation needed for high-stakes online gaming. The keys require a decent amount of pressure to register input, which will be preferred by some typists and hated by others. The Whisper Quiet keys are also only rated for 20 million keypresses, which sounds like a lot, but is less than half the lifetime of the average modern mechanical key.

There's no USB passthrough or removable power cable here, which is a shame—and another pair of features that gamers will most likely miss. On the flip side, the 10-zone RGB can be set up to react with colorful effects to games or Discord, like a whole-keyboard pulse of white when you receive a notification. The tri-directional cable-routing solution on the underside is exactly the same as you'll see in other Apex keyboards, and it remains a brilliant yet simple desk-tidying tool that we wish other manufacturers would take note of.

The last touted feature of the Apex 3 is its IP32 durability rating. The membrane keyboard is actually what enables this, since it seals off the electrical components of the board. IP32 is an international standard specifically for water and dust resistance, and SteelSeries assured us that while it won't survive a dip in the ocean, the Apex 3 should be completely unaffected if we spill our Redbull on it. It even has built-in drainage holes in the bottom!

The Apex 3 isn't going to set the world on fire, but if you prefer membrane to mechanical keys, it's an excellent and reasonably priced option. The quiet keys were certainly enjoyed by this reviewer's partner during testing (it's now back to the clattering of mechanical keys for them). Yes, it's somewhat feature-light, but for $50 we can hardly complain.

–CHRISTIAN GUYTON

VERDICT **8**

SteelSeries Apex 3

ZENITH Great value; robust construction; very quiet.

CHASM Keys feel spongy; not great for gaming; no USB passthrough.

$50, steelseries.com

SPECIFICATIONS

Switch Type	SteelSeries Whisper Quiet switch
Switch Durability	20 million presses
Media Keys	Dedicated key and scroll wheel
Connection	N/A
Battery Life	N/A
Wrist-rest	Magnetic rubberized
Dimensions	6.0 x 17.5 x 1.6 inches

ASUS ROG Chakram

A feature-packed wireless gaming mouse that even has a joystick

ASUS IS WELL-KNOWN for its motherboard and GPU lineup, but its peripheral range is sometimes overlooked. Don't get us wrong, many other options are cheaper, and the ROG tax can hit the user hard, but if you put the price aside, its products are usually solid. The ASUS ROG Chakram is the latest mouse we're looking at from the company, and despite appearing very familiar at first glance, Asus has implemented some features that we rarely see at this price point, some of which are done impressively well.

The Chakram is certainly pricey. It retails officially at $150, but it is worth searching for other deals, as we found it for $120 at some retailers. For this price, you get a PixArt PAW 3335 sensor. This has been designed specifically to have better power efficiency for use with wireless mice. The sensor did very well in all of our testing, and tracked over multiple surfaces without skipping a beat. It's accurate and responsive and is what you'd expect from a mouse at this price. It has a maximum CPI of 16,000 and has pre-set, on-the-fly, settings for 400, 800, 1600 and 3,200. The Chakram can be used straight out of the box, but for many features, such as customizing the three RGB zones and setting macros, you will need the ASUS Armoury II software.

The mouse is incredibly comfortable. This is subjective, of course, but it is not very often we can go from using our mouse to a test sample without a few days of getting used to it. The build quality is high, and although there is some slight movement in the shell and the buttons—due to the hot-swappable Omron switches and the screwless magnetic removable back—it is barely noticeable, and the comfort and usability experience is great. The mouse weighs in at 4.4 ounces on our scales, so if you are looking for a light mouse, then this is not the one for you. It has two wireless modes and a USB-C wired mode. We used the 2.4GHz one mainly, and only used the wire while charging. The mouse does have Qi charging if you have a compatible charger. Bluetooth is great for office work or for connecting to other devices, but for gaming we overlooked it—it's just not worth it when you have two far better options.

JOY(LESS)STICK

The star of the show is meant to be the joystick. This can be swapped from a short stem to a long stem and can also be blanked off entirely. Unfortunately, the short stem joystick arrived broken out of the box. For a $150 mouse this really should not happen. The joystick works well in games and tests. It does everything it advertises, but it just doesn't feel that intuitive; it feels more like an add-on rather than a seamless incorporation. It's spongy and has little to no feedback, but that's not necessarily a bad thing. Despite the ease of setup and use in games, it is more of a gimmick rather than a feature. We were forcing ourselves to use it rather than using it naturally. Those with small hands may find the joystick just too far out of reach as well. A palm or fingertip grip worked best for us—a claw grip feels rather awkward, especially if you wish to use the joystick.

The ASUS ROG Chakram ticks so many boxes: It's comfortable, accurate, has great hot-swappable switches, and even has a nice carry case. But the main feature just doesn't do it for us. If you are someone who feels like the joystick will really change your gaming experience, spend the money and enjoy the Chakram. But if ASUS dropped the joystick and the price, the Chakram could have been a different beast entirely. It could have quite easily contented itself as one of the best wireless mice of 2020. **–DAVE ALCOCK**

VERDICT **8**

ASUS ROG Chakram

SHARPENED STEEL Comfortable; hot-swappable switches; great wireless options.

DULL BLADE The joystick is more of a chorestick; expensive.

$159.99 www.asus.com

SPECIFICATIONS

Mouse	ASUS ROG Chakram
Sensor	PixArt PAW 3335 Optical
Max Sensitivity / IPS	16,000 CPI / 400
Polling rate	1000 Hz
Programmable buttons	5 + Joystick
Weight	4.4 Oz
Battery life	70 hours (no illumination)
Connection Standard	2.4GHz wireless, Bluetooth, USB-C cable

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Phanteks Eclipse P500A

Maximum mesh

PHANTEKS OFFERS a massive variety of PC cases, from hulking full towers to diminutive ITX boxes. Yet they're still finding holes to plug within their own range, and that's what the P500A does. It's not the most expensive Eclipse case, but it's still a large, premium case with space for E-ATX boards, capable of containing a powerful system.

Airflow is the name of the game here. The entire front panel is carved from a single flat piece of metal and employs Phanteks's "ultra-fine performance mesh," with 1mm perforation that provides a large, flat surface for air intake. As any mesh-heads will know, mesh cases eliminate the need for removable dust filters, allowing for superior airflow.

Three 140mm D-RGB fans (or two plain black ones if you opt for the cheaper RGB-less model) sit behind that mesh panel. Connected to a software-less RGB controller inside the case, these draw in plenty of air to be vented through the rear and roof of the case. The P500A doesn't come with a rear fan, but transplanting one of the front fans shouldn't be hard. A single 140mm fan also isn't that expensive.

Speaking of pricing, this P500A will run you $130. It's not the cheapest RGB mid-tower case we've ever seen, but the metal and tempered-glass construction here feel up to snuff for the cost. It comes with removable roof and base dust filters, and an accessory kit packed with extras.

This is something of a feature-heavy case. The RGB fans are joined by a matching light strip that runs across the PSU shroud, all behind a hinged glass window utilizing a triple-fin rubber seal to reduce system noise. It's not perfect, as the mesh front panel lets noise out, but it's a welcome inclusion. There's room for more fans or radiators, with up to 360mm of radiator space in the roof should you decide to liquid-cool your build.

Storage is fully handled here, with mounts for up to three 2.5-inch SATA drives behind the motherboard, and 10 slots (six within the case cavity, four underneath the PSU drive) where HDD brackets can be mounted. The case comes with only two of these brackets included.

Similarly, a bracket to vertically mount your GPU is included, but the required flexible PCIe riser isn't. And four drilled holes in the roof of the case allow for a secondary ITX system to be installed, but the bracket and miniature PSU needed are sold separately.

There's a lot to enjoy in this case, though. For example, cables can be tidied using the sliding plates attached to the central mounting plate. They're simple to use: Slide them open, feed your cables through, then slide them back into place and lock them with the attached thumbscrew. The D-RGB lighting uses color and pattern presets that can be changed via two buttons on the front I/O, and the I/O also includes USB Type-C.

In short, this case has everything we'd expect from a product in the realm of $150, and it's $20 cheaper than that. It's hard not to like. Those HDD cages can hold 2.5-inch drives too, so there's basically no case within this price range that can compete on a storage capacity level. We've seen better premium mid-tower cases, but they are also more expensive. Solid value matched with solid construction makes this an attractive option for anyone looking to build a powerful gaming system or workstation. –CHRISTIAN GUYTON

VERDICT **9**

Phanteks Eclipse P500A D-RGB Black

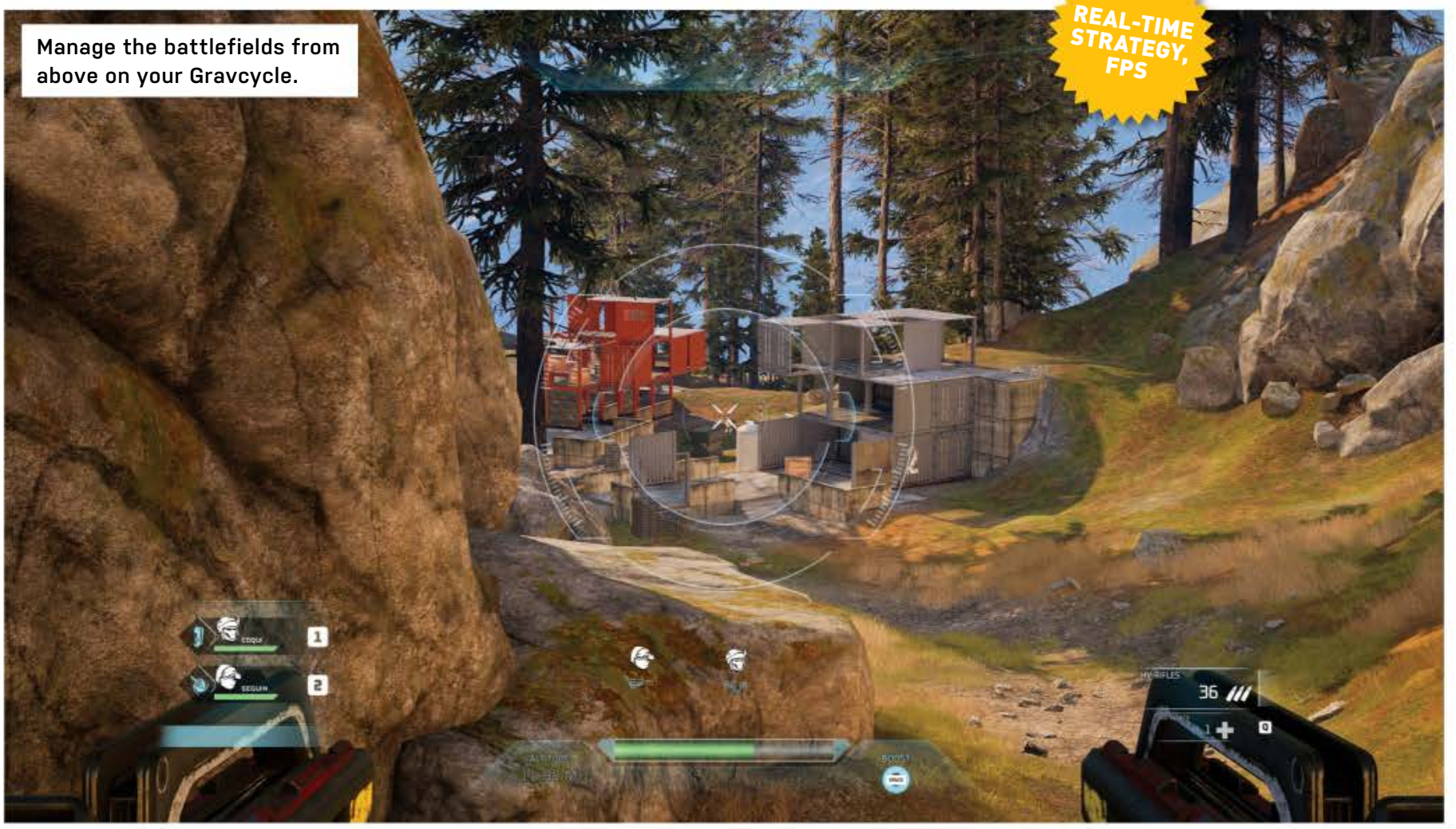
SOLAR POWER Excellent airflow; a solid construction; lots of features.

OVERCAST Requires some paid extras for maximum style; fans are a bit noisy.

$130, phanteks.com

SPECIFICATIONS

Form Factor	Mid Tower
Motherboard Support	E-ATX, ATX, mATX, ITX
Colors Available	White, Black
Window Available	Yes
3.5-inch Support	2 + 10
2.5-inch Support	3
Radiator Support	420mm (front), 360mm (top), 140mm (rear)
Fan Support	3 x 140mm (front), 3 x 120mm (top), 1 x 140mm (rear)
Dimensions	12.8 x 24 x 24 inches
Graphics Card Clearance	17.2 inches
CPU Tower Clearance	7.5 inches
Weight	22 lbs



Disintegration

Things fall apart

PART OF THE HYPE around *Disintegration* has centered on the presence in the game director's seat of one of the co-creators of *Halo*. *Disintegration* takes an odd approach: This is a shooting-management game, where the manager has a big gun.

Positioned up to 15m above the battlefield on a "Gravcycle," shooter-manager Romer Shoal has a couple of guns, a healing ray, and up to four troopers with abilities that he can direct to move, attack, or use a special weapon.

Adapted from a racing machine, the Gravcycle is meant to swoop gracefully around the battlefield, dodging enemy fire and issuing commands, all while firing to take down heavier threats and heal allies. In reality, you spend as much time hovering in place, dishing out priority targets and manoeuvering close to green healing nanites. Your troopers aren't mindless drones, though—they'll attack whichever enemy is closest or is firing at them, and follow when you move on.

Your secondary role is to collect salvage dropped by downed enemies, which feeds into the progression system. There's a lot going on, especially as new squads of enemies are frequently dropped into battle, so keeping track of where your troops are, their health levels, and what threats are in the area become key.

Almost every character in the game is a robot. Human consciousnesses have been transferred into robot bodies, a process known as "integration," which leads to bizarre affectations such as robots wearing leather jackets and, right in the opening sequence, your character knocking another robot out with a wrench to the head. The game suffers from this lack of a firm identity throughout, though sadly the enemies don't—their lack of diversity, especially early in the game, paints them indelibly on your memory. The enemy designs are rather good, and they explode nicely, taking the edge off their repetitive nature somewhat, so it's a shame you only see them from the elevated position of your Gravcycle.

The tactical elements are sadly limited. Having a large robot on your squad along with two smaller members, it would make sense to send the big guy against bigger enemies while the other two mop up the little guys. But prioritize a target and your entire squad goes for it; set an objective and they all go in that direction. The closest you get to granularity is in special abilities, as using a concussion grenade, for example, means only the squad member with that ability will go in for a throw. By the time they get into range of your target, however, the tactical situation may have changed so much as to make their intervention pointless.

Between missions you can walk around and talk to your squad members, but you get no choice in which ones accompany you on missions. This sums up *Disintegration*: For a game in which you're offered so much control, you end up feeling like you have very little. **–IAN EVENDEN**

VERDICT **6**

Disintegration

SHATTER Looks good; excellent robots; setting has lots of potential.

SPLATTER Guns feel a bit weedy; lack of control over squad; management can feel like a chore.

RECOMMENDED SPECS CPU, i7-8700 or Ryzen 7 3800X. RAM, 16GB. GPU, GTX 1060 6GB or RX 5700 XT.

$50, disintegrationgame.com, rated T for Teen

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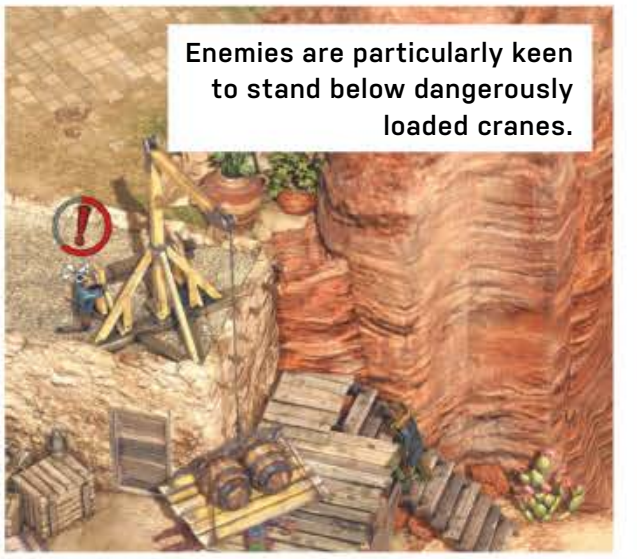
Use stealth tactics to take out powerful bad guys.


Enemies are particularly keen to stand below dangerously loaded cranes.

Lead Cooper and his gang on a quest of redemption.

The Western setting creates atmospheric levels.

REAL-TIME TACTICAL WESTERN

Desperados III

The quiet bunch

THE BANDITS OF THE WILD WEST are an inquisitive bunch. They can be enticed to wander away from their buddies by something as innocuous as seeing a cat, or discovering footprints. A medical bag thumping down just inside their cone of vision is irresistible, curiosity overcoming all fear when near railroad tracks or the dangerous end of a horse. Funnily enough, the hard-eyed outlaws who go to investigate these things don't come back.

Desperados III is from the same studio that brought us *Shadow Tactics* in 2016, and hews closely to the real-time stealth tactics template laid down in that game, inherited from the *Commandos* and *Desperados* games of the late 90s and early 00s. This being the Wild West, everybody has guns, but guns are loud, and noise brings bandits. The bad guys are more than capable of killing your team of infiltrators, and the guards they can summon will finish you off easily.

This is a game of stealth and teamwork, of hiding bodies in bushes and exploiting the curious cowboys who find nothing wrong with their compadres vanishing as long as they don't see it. Right-clicking on a bad guy gives you their vision cone, suitably graduated to reveal the effect of distance and cover. Stay out of those cones, don't make a noise, and you can get away with anything. Lead character John Cooper has two six-shooters, but your main weapons are quick-save and quick-load, the game actively encouraging you to bang away at F5. This takes nothing away from the tension, with each arrangement of outlaws, cover, and environmental hazards its own puzzle to solve.

The bandits here love to stand in the shadow of loose rocks, or below piles of wood suspended from cranes. Special enemies have particular attributes signalled by their attire: Poncho-wearers are impossible to distract, and those in long coats are particularly tough. These guys are ripe for leaving until last, before dispatching with a long-range shot or the hatchet of your strongest fighter. One character's voodoo magic enables you to kill multiple enemies at once or turn guards on each other, which leads to *Hitman*-like levels of planning as your gunfighters skulk in the bushes, wriggling into position before springing their trap.

Not all levels are straightforward slaughters, however. Some take a more investigative form in which you don't need to hide, but listen to street chatter to identify both target and method of dispatch. The environmental kills take a larger role in these sections, as you make deaths look like accidents, the booms these unproblematic exits make providing a satisfying payoff for all the sneaking around that leads up to them. Badges, optional objectives you're told about after a level, along with time targets, encourage replay, and you're treated to a map-view replay of your actions once a section is complete—all the better to scrutinize and improve your tactics.

We're not sure whether it's the change of setting or that developer Mimimi Games has learned a lot since *Shadow Tactics*, but this is the more compelling of the two games, and our dusty heroes here have a profane charm that's entirely suitable. **–IAN EVENDEN**

VERDICT 8

Desperados III

DEAD GOOD Stealth tactics in the Wild West; sharp graphics; good performance.

DEADWOOD Lots of cussin'; no character stands out; do cowboys and voodoo mix?

RECOMMENDED SPECS CPU, 3GHz quad-core. RAM, 12GB. GPU, GTX 760, Radeon HD 7870.

$50, desperadosgame.com, Rated M

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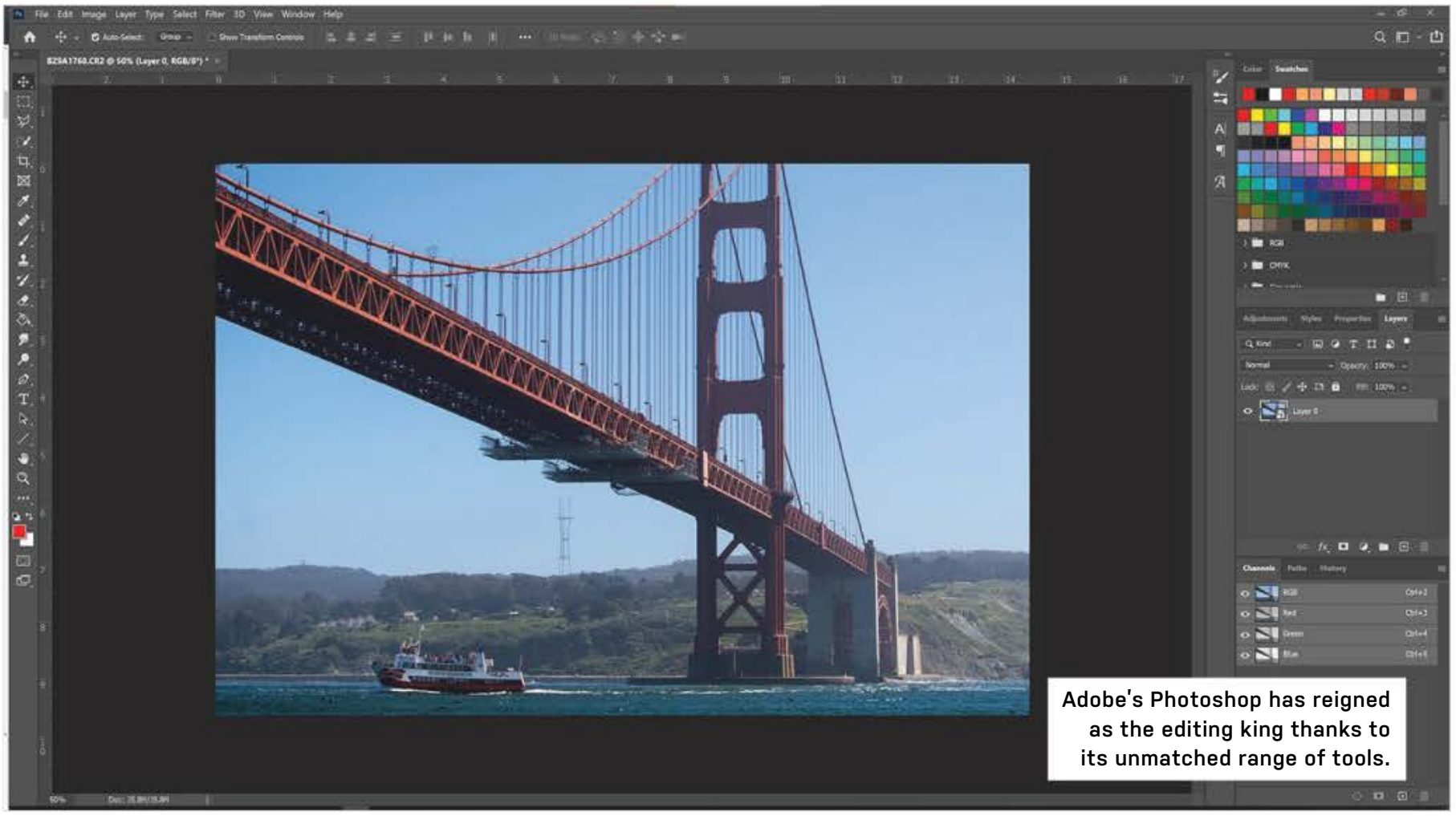


Adobe's Photoshop has reigned as the editing king thanks to its unmatched range of tools.

Adobe Photoshop CC 2020 vs Affinity Photo 2020

In the battle of the image-editing apps, there's only one winner: the users

THE WORLD OF professional image-editing applications is not a wide one. There's Adobe Photoshop, and then there's everything else: Maybe PaintShop Pro or PhotoPaint from Corel, or the open-source GIMP, or Paint.net if your needs aren't very great. Then Serif, maker of the also-ran app Serif PhotoPlus, decided to play Adobe at its own game with the Affinity suite. First came Affinity Designer, then Affinity Photo, then Affinity Publisher, rivalling Illustrator, Photoshop, and InDesign in terms of features and usability.

Serif is quick to retweet stories on social media of professionals abandoning Photoshop for Affinity Photo, often underlining the difference in payment schemes adopted by the two software developers. But just how similar are the two programs? And can someone who's been using Photoshop for 20 years navigate a new app?

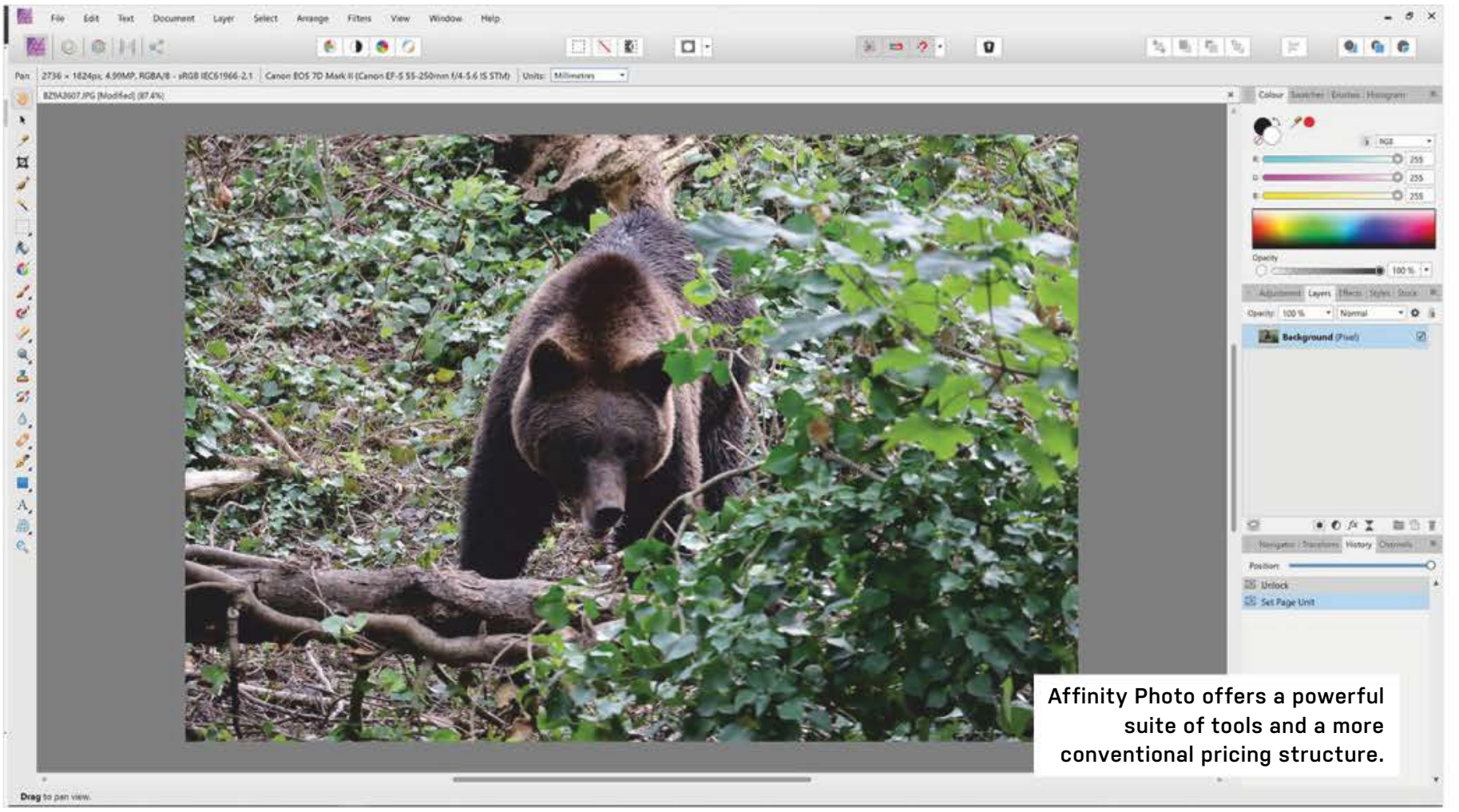
Perhaps the biggest difference between the two apps is the way you pay for them. Photoshop is part of Adobe's notorious Creative Cloud suite of subscription-only apps, but differs slightly in that it can be obtained (along with RAW-processing and image-organization app Lightroom) as part of the bargain-priced Photography Plan, which at $9.99 a month is half the price of a subscription to any other single app. Alternatively, you can splash out $52.99 a month for the entire software suite, which numbers more than 20 apps.

Affinity does things the old-fashioned way. For $50 you get the desktop app, and another $20 on top nets you the iPad app. You're free to add the other two apps in the suite too for the same price, except that Publisher doesn't have an iPad app yet. All updates are then free. Some people prefer this, as they don't like the idea of renting software, while others prefer the subscription model. It's a matter of personal taste, but whichever app suite you choose, you're stuck with its pricing.

A NEW CHALLENGER

The two apps are both layer-based raster image editors with vector capabilities, and Affinity Photo has clearly been made with Photoshop users squarely in mind. From the gray background (adjustable, and there are light and dark modes) to the interoperability with Photoshop's PSD files and plugins, to the positions and names of tools and palettes, this is the sincerest form of flattery.

Possibly the best thing Affinity ever did, however, was to sting Adobe into action. Just as Intel's CPU lineup had stagnated until Ryzen came along, so Adobe's updates were decidedly pedestrian before the release of a serious rival. Since then, however, it's gone nuts. New content-aware features, some of which make use of Adobe's Sensei AI cloud tech, make selecting difficult features, such as curly hair, much easier. Content-aware selection is now able to detect whether the object being selected is a person, and changes to a different set of algorithms if



Affinity Photo offers a powerful suite of tools and a more conventional pricing structure.

it is. Affinity has updated its own selection tools with a "Selection Brush" and "Refine" window that works like "Select & Mask"—but Adobe's ahead here.

Sensei also comes into play with the new "Match Font" feature, which will identify fonts used in signs or shopfronts you've photographed, and match them to something similar on Adobe Fonts. It works across multiple lines, and even with vertical text.

Meanwhile, Serif has been concentrating on catching up to Adobe in other areas. Affinity Photo now supports "smart" objects (layers are smart in Affinity Photo by default, without needing to be converted, so can be resized non-destructively), and has full compatibility with DXO's Nik Collection of plugins, which apply their own algorithms to things like noise reduction, sharpening, geometric corrections, and film simulations in ways that are popular with many photographers and image editors. With more than 200 presets, you're never short of a place to start.

And while Affinity Photo may seem to lag behind, it's an app that's still in active development. For example, while the Mac version works with multiple GPUs, that feature hasn't come to the PC at the time of writing, but is promised in a future update. Affinity's major advantage over Photoshop comes in its usability: the Affinity interface is split into different workspaces, which it calls "personas," each of which has a specific task. So there's the "Develop" persona for dealing with RAW image files, the "Photo" persona where the bulk of the editing takes place, the "Liquify" persona for warping effects, the "Tone Mapping" persona for HDR, and the "Export" persona for, well, exporting.

In addition, the three Affinity apps support StudioLink, which allows Affinity Designer users to edit an image right there in the layout app but invoking the photo-editing app's tools. Flicking from InDesign to Photoshop and back if you want to correct something in an image file doesn't take long, but with StudioLink it's pretty much instant. The apps are also built around a common file format, so you can open a Publisher document in Affinity Photo and edit it as if it were an image file.

Serif has lavished attention on Affinity Photo's "Move" tool, which works with the "smart" nature of layers to make resizing an object easy, rather than Adobe's habit of making you jump through a couple of hoops first. Then there are Affinity's live previews, which show exactly how your chosen combination of brush, color, and opacity settings will paint before you do it—something Photoshop doesn't have. Otherwise the two apps are both excellent layer-based raster image editors, and you can't go wrong with either.

Choosing between these apps is like choosing a racehorse. Do you go for the established champ, or the up-and-comer who might stand a chance of leading the field one day? A lot will come down to your views on subscription pricing—and if your clients demand an Adobe workflow, then there's no substitute. But don't rule Affinity out: It does a lot right, and if the improvements keep coming the way they have been, it really does stand a chance of coming at the king, and not missing. –IAN EVENDEN

VERDICT 9

Adobe Photoshop CC 2020

ANNIE LEIBOVITZ Industry standard; interesting Sensei tools; ties into the CC suite.

PARIS HILTON Complex; Some may balk at the pricing structure.

RECOMMENDED SPECS 1.6GHz CPU or better, 8GB RAM, 7.6GB of storage.

Photography bundle $10/Mo, www.adobe.com

VERDICT 8

Affinity Photo 2020

ALL THE GEAR Single purchase; solid foundations; Affinity StudioLink.

NO IDEA Can't match Adobe's special effects and AI tools.

RECOMMENDED SPECS Processor with x64 Support (Core 2 Duo onwards), 4GB RAM, 702MB of storage.

Single purchase $50, www.affinity.serif.com.

LAB NOTES

ZAK STOREY, EDITOR

Not Enough Time

Letting go of gaming

LAST YEAR, for my 28th birthday, I decided to spend it in Norway. It was a big plus for me because I don't like being the center of attention, especially around that day, and I'm quite an introvert too, so getting away from everything was perfect.

In October, myself, my fiancée, and two of my friends flew to Bergen, and then drove from there to a quiet little town called Stranda in Møre og Romsdal. Honestly, it was the most relaxing experience of my entire life. We didn't really do much, but nonetheless the country had quite the effect on myself and my future wife.

To that end, we've both decided to move there one day, and make it our (forgive me, I hate this phrase) "forever home." At least, we will when the time is right for us to start a family. Whether it's the language, the food, or the culture, it all just meshes with us both really well, and I have family roots there too. I know it's not an easy thing to do, I'm no stranger to the difficulties involved in moving to another country, but it's something we both want.

This is years and years away for sure, I'm not about to leave *Maximum PC* any time soon. However, if I do want to do this, there's a ton of work that needs to be done to get myself ready for that moment. The older I'm getting, though, the more I'm beginning to realize that I just don't have the same amount of free time as I used to. I can't pour hours and hours into gaming like I do today.

To that end, I'm going to relegate it to one night a week, just so I can be more productive. After all, I've got a magazine brand to bring back into the digital world, a relationship with future Mrs Storey to maintain, a language to learn, and I even want to start collecting Warhammer miniatures again (don't ask). Don't get me wrong, I'm still going to be building PCs like a maniac, but if I really want this, I have to make that commitment.

Norway's one of the most beautiful countries I've ever seen.

INDUSTRY INSIDER

How does one decide which game to play when one settles down for a quiet evening enveloped by the warm glow of a PC screen? You could try something new, or default to the same handful of titles you know and love. You could create a list of games you want to play, then work through it in order. If you're nuts, you could create a detailed 289-row Google Sheets database assigning various weighted scores to games in order to figure out the optimal playing order. (It's me, I'm nuts.)

Valve's been figuring out the best way to get players to buy something new on Steam, rather than playing a free-to-play battle royale for the 273,054th time. This is Steam Labs. From personalized search functionality to AI-generated six-second trailers, it's been a wild ride.

Valve's Community Recommendations is a new feature where an automated system pulls popular user reviews for games and slaps them on Steam's homepage. Unfortunately, this is flawed; popular reviews aren't always positive, nor are they that child-friendly. A skim through some revealed swearing and crude jokes galore, along with a number of simply damning reviews. Valve claimed it sought to foster Steam's knowledgeable community, but this isn't what it had in mind.

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Mayhems Glass Cutter

ONE OF THE PERKS of being in this industry is that you get to get hands on with a lot of kit early. Tons of engineering samples and concept ideas typically head our way before they go into production. It's kind of something companies do, especially the smaller ones, to get our insight into things and see how they can improve stuff before pitching and selling products to the public. It's cool, because obviously this is new stuff that we're trying for the first time, but the flip-side is that sometimes (not in this case) you come up against things that don't quite have the same durability, or warranty, or quality as something that's manufactured and ready to go.

So when Mayhems offered me the opportunity to take a look at its Glass Cutting Tube Kit prototype I reluctantly, after much pressuring, said yes. So what exactly is it? Well in liquid-cooling you get two types of tubing: Hard and soft. Soft is typically flexible rubber, or a polyethylene substitute. And hard tubing covers a wider range, including everything from acrylic and PETG, to copper, brass, carbon, and even glass.

Excluding PETG and acrylic, the latter lot are quite problematic to deal with. They're difficult to work and challenging to create bends with, if not impossible in some cases. However, they're also at the very cutting edge of premium. And in a world where custom liquid-cooling is getting more and more accessible, and the adept are becoming more skilled, trying to find something to stand out from the crowd becomes ever more appealing.

Borosilicate glass tubing has by far the highest clarity level, and is more resistant to corrosion and color leaching than any other type of tubing, and to that end it is very attractive to use. You can even buy it in pre-bent 90-degree angles to get back those bends (otherwise you're using a blowtorch to do it). However, traditionally the only way to cut it is by using a Dremel and a cutting wheel attachment to slice the tubing in half. Because of the nature of the particles you're spitting out by doing that, you also need to wear a filtered dust mask to minimize exposure to the silica, which can cause silicosis and long-term lung damage in the form of fibrosis. Once cut, you then wet-sand your tubing,to bevel off the edges, ready for fitment.

Mayhems' Glass Cutting Tube kit helps you effectively cut the tubing in half without using a Dremel or producing excess levels of silica dust. Simply put, it uses a small cutting edge, pressure, a touch of cutting oil, and the force of your hand to score the tube at the point in which you wish to make your cut. Once scored enough, you take the tube out, and with two hands carefully put pressure on either side of the score with your thumbs and push away from you. The tube splits perfectly down the score, and requires a minimal amount of sanding. It's a flatpack design, constructed from plastic, and is capable of functioning with 12, 13, and 16mm glass tubing.

It makes glass tubing far easier to work with, but there's some trepidation for first-time users like myself. Snapping a glass tube is still quite intimidating, and making sure your measurements are perfectly accurate is also daunting. With acrylic you can take a little bit more off if you make a mistake, but with glass the options are far more limited. However, if you do want to push yourself into the boundaries of supreme liquid-cooled tubing, this might just be the perfect solution for you. **–ZS**

$31.62, www.mayhems.net

EDITOR'S PICK

Christian Guyton, Staff Writer

MORTAL SHELL

I recently got stuck into the beta of *Mortal Shell*, a *Dark-Souls*-aping action-RPG from developer Cold Symmetry. *Mortal Shell*'s world is bleak and dark, with deadly traps and murderous enemies lurking around every corner.

It feels like a condensed version of the *Soulsborne* games. The melee combat is similar: Lock onto targets one at a time, strafing around them to avoid getting hit and trying to land your own blows when you see an opening. It does pinch one key feature from *Bloodborne*, where executing a well-timed parry and counterattack rewards you with health recovery. Otherwise, this is a game of caution. Even basic enemies can rapidly deplete your health, and most will pursue you with dogged aggression. Powerful foes can strike you down with a single hit.

Much like *Dark Souls*, death is not necessarily the end. Upon receiving a killing blow, you won't die instantly; instead, your weird bony soul-form is blasted out of your physical body (the titular "mortal shell") and you can keep fighting. The catch is that your spirit is fragile; One hit and you're done. You can use the spirit form to return to the relative safety of your shell, or try to get in a few high-risk attacks. Get knocked out of your body more than once and it's back to the last checkpoint with you.

Mortal Shell is seriously hard. Enemies hit harder than in From Software's famously challenging titles, and often a single mistake means instant death. My interest is certainly piqued with this game, but I hope Cold Symmetry can refine the difficulty just a little before launch.

$30, mortalshell.com

© MORTALSHELL.COM

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Data Analysis
> Case Construction
> Microsoft Edge

Case Conundrums

Hi folks—long-time reader and love the mag. I have a Maingear Shift PC that's getting long in the tooth (seven-year-old Haswell processor, one panel doesn't stay in). I'm looking into building a new PC. One minor question, and don't laugh: My PC sits between my desk and sofa, and because of the height of the PC, it's a fantastic drink-holder as the height is exactly the same level as the arm on my sofa. Is there an equivalent-sized new case that's easy to build in that you would recommend? The sharp edges of the Shift were another detriment, although it looks great—thanks! **–Jerry**

EDITOR ZAK STOREY RESPONDS: This is a tough one, actually more because the dimensions are incredibly difficult to source. We've found a review from *Tom's Guide* back in 2014 for the Maingear Shift that seems to be the only place that lists the case's height. And even then they've failed to list in which order those dimensions are measured, so we're assuming that it's 24 inches tall. It's a bit problematic as there's a ton of full towers but some are much taller than that, others much shorter, and some have bizarre top-panel design features, which are a bit annoying if you're trying to keep a drink on there. One of the closest we can find to that height is be quiet!'s Dark Base Pro 900, but it comes in just slightly shorter at 23 inches.

What I might be more tempted to recommend is that you build some sort of small plinth for your PC out of a few off-cuts of wood, or something along those lines. It's a small bit of DIY, but that way you can control exactly how high your PC case is, and it gives you access to more cases, as you'll only need to adjust the height of your plinth. It's also a good idea if your PC is sat on carpet, as you can keep it lifted off the ground and it'll give the power supply fan (if it's facing down) better access to cool air.

I'm a fan of using recycled pallet wood for DIY projects, as long as you get the right stuff to use indoors. It gives things a rustic feel, and you can paint it, stain it, or oil it whatever color you want to match the rest of your furniture. Also, if you're not great at woodwork you can claim it's "meant to look that way because it's rustic." I found a place local to me that sells recycled pallet wood boards at 25 cents per foot, so it's worth checking out.

[CORRECTION]

Last issue on page 53, we mentioned that you should unplug fans during the cleaning process, as the motors can generate an electrical charge when spun quickly. It's worth noting this is no longer the case with new fan motor designs. Thanks to Carey Holzman for pointing this out. Check out his video disproving the tech myth here: bit.ly/20JTKMQ

Microsoft Edge Virus

Hi, In other circumstances, I might have been willing to give MS Edge a go, say if they offered it for download like almost every other browser in the world. But the way that MS jammed it down my throat, making it next to impossible to uninstall (even through power shell) and having it run at startup in spite of being disabled in Task Manager... it's a bit much. I was able to get it off my computer after much fiddling around (booting to Linux Live, etc) but what are they thinking? **–Steve G**

EDITOR ZAK STOREY RESPONDS: I'm so glad you gave me the opportunity to rant about this, because I can't even begin to explain to you how frustrated I was when that update came around, and it was like "try Microsoft Edge," massive full-screen window, no way of clicking out of it without hitting continue, then it offered to import all of my Firefox bookmarks. Absolutely agree with you, it's obtuse and reeks of that same notion back when Apple added that U2 album to everyone's iPhones.

It certainly doesn't help its case, I know Edge is now a lot better than what it used to be, it's basically just a spin-off of Google's Chromium, complete with access to its extensions and so on, but it's a bit gross really. That said, once I got past the update, I unpinned the icon from my Windows bar, deleted the icon from my desktop and it hasn't bothered me since. The only thing I do

↘ submit your questions to: comments@maximumpc.com

use it for currently is to open PDFs I download on Firefox, and that's about it.

Interesting to know you can get rid of it entirely by delving into Linux. I might have to get the guys in the lab to write something up on that.

The Ultimate Data Scientist's Rig

I read the letter from Tali Kadosh in your June 2020 issue, and I'd like to make a similar request. Like Tali, I'm not into gaming, but I enjoy reading your magazine to keep up with the latest developments. I've never done my own build, but would like to do so in the next year or so.

I'm glad to know you have an issue coming out soon that will feature a build not necessarily targeted at gamers, but I would like to suggest another specific build for a future issue. My interest is in the field of data science, and my suggestion is to feature a build worthy of being called "The Ultimate Data Scientist's Rig."

Many of the tasks data scientists perform are incredibly resource-intensive. Beyond performing traditional statistical analysis on large datasets, a PC's limits can really be put to the test by machine learning and deep learning models. Not only is there a need for a great deal of processing capacity and memory, but results often need to be displayed in sophisticated data visualizations. Therefore, graphics processing capability is also a concern, although perhaps not as much as it is for your gamers.

Given that "Data Scientist" was considered the #1 job in America four years in a row by Glassdoor, and is still ranked #3 in 2020, I'm sure such a feature would be very well-received. And I'm guessing your crew would enjoy doing this type of build very much!

–Vincent Thompson

EDITOR ZAK STOREY RESPONDS: I will thank you in advance, because we're going to cover this topic next issue on the back of your email. It's quite the interesting build you've recommended, and I've been chatting with Christian a lot about how best to do this. We've been seeing what parts we can get in, and currently have a build list sitting at around the $3,000-$4,000 mark, which I know sounds a bit pricey, but should hit the nail on the head for superior dataset performance.

Threadripper's going to be at that heart of this build, I won't give too much away about the rest of the spec, but we're looking at pairing AMD's Ryzen Threadripper 3970X—which gives us access to 32 cores and 64 threads—with 128GB of high-speed DDR4. Although it's worth noting that this isn't going to be ECC memory or anything along those lines (way too expensive), so you'd need to recheck your calculations on a "proper" data analysis system. We're also going to offer some ideas for downgrades and other options you could pick if the price seems a bit insane.

This also gave me some inspiration during our benchmark recalibration for the coming year. You'll notice we're including a protein-folding benchmark, and CompuBench's N-Body simulation test as well.

[NOW ONLINE]

CORE I9-9900K VS. RYZEN 9 3900X

If we're talking pure performance, it's easy enough to point to the best graphics card for gaming and the best CPU for gaming. Today, the fastest graphics card is the RTX 2080 Ti, and the fastest CPU for gaming is the Core i9-10900K. Our GPU test system still uses a Core i9-9900K (the newer stepping D, revision R0, which can improve performance 3-5 percent depending on the game), but we wanted to provide a complete look at how two of the top CPUs stack up, across a full suite of games and resolutions, with a much wider selection of graphics cards.

Read the article here: https://bit.ly/AMDvsIntelGaming

No Microsoft Teams?

I've been a long-time subscriber and gadget wonk. I've been building PCs and servers for ages, and I enjoy your magazine.

I was reading through my July 2020 issue and Christian Guyton's work-from-home primer. As an IT consultant for years and a work-from-home regular, I enjoyed Christian's article but was surprised by his failure to mention Microsoft Teams as a UC (unified communications) tool/platform. Teams evolved out of Skype for Business, and it is the primary way through which many of us communicate and do remote business these days. I saw that Zoom was mentioned and described, but many IT organizations positively forbid the use of Zoom in business-related dealings due to recent (and significant) security gaps. Teams comes with just about every Microsoft 365 (formerly Office 365) subscription, so it's ubiquitous and readily available to most work-from-home people.

As a long-time supporter of Microsoft (and recently renewed Microsoft MVP), I'd be remiss if I didn't point out this apparent oversight. Several of us in the MVP community host a regular twice-weekly webcast (bit.ly/39heZyS) and maintain a Facebook group page (bit.ly/2WIapod) to help people understand and use Teams more effectively, as well as answer any questions. I would be eternally grateful if you spent a little time raising awareness of Teams in a future issue. Keep up the awesome work, and steer clear of Rona!

–Sean McDonough

EDITOR ZAK STOREY RESPONDS: I think really it's just a lack of experience on our part. Our publishing house in particular is a Google House, so neither myself nor Christian have much experience when it comes to using Microsoft Teams in a professional manner. However, I do agree with you, it's something we should cover going forward.

I don't really see life changing that much at this point. I think this new normal of ours, and working from home, is only going to accelerate going forward, especially as so many companies are finding that the vast majority of their staff can effectively work from home for far less cost to them. That's great news for anyone in the PC industry.

We've already planned the next issue, but I will schedule a tutorial for the issue after, going through how to use teams, it will be beneficial for everyone I think—even the *Maximum PC* team!

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THE BUILDS

BUDGET

BOTH BUDGET BUILDS have seen small savings this month, although only the Intel system managed to dip below the $800 mark. Intel's current lead is mostly due to a decent price drop on the i5-9600K processor, which now costs a very attractive $190. We've made plenty of changes here; first, both motherboards are now Phantom Gaming 4 models from ASRock. The Intel build has received the Z390 mobo because it's the most affordable option, but the AMD build has given us a chance to both upgrade and make a saving with a new B550 board, bringing us forward a generation.

This should see minor general improvements in performance and power management, but the crucial addition is PCIe 4.0 support, allowing us to use 4th-gen M.2 SSDs for maximum transfer speeds. We're not doing that yet, though. Why? Because this is a budget build, and currently the smallest PCIe 4.0 drives available are all 500GB models costing upwards of $100. Still, there's a good range of cheap, low-capacity SATA III SSDs available now, so we've swapped the boot drives in both builds for 120GB Teamgroup GX1 SSDs. If cheaper PCIe 4.0 SSDs become available soon, we'll take advantage of them.

The GPUs didn't need changing, although a promotion on the EVGA GTX 1660 Super Black Gaming saved $15 for the Intel system. The 5600 XT is still slightly expensive for our liking, but it does perform well. We've also coalesced back down to a single PSU for both builds, with the ever-reliable EVGA 450 BR. While similar power supplies are sometimes cheaper during sales, the 450 BR remains an excellent deal. The last change we've made is the memory in the AMD system, with a switch to a different 2x16GB kit to shave a few dollars off the price while keeping the same frequency and CAS latency. Performance isn't improved hugely in either system this month, but we've saved a bit of money and gained some small boosts here and there.

AMD INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$70
PSU	450W EVGA 450 BR **NEW**	$50
Mobo	ASRock B550 Phantom Gaming 4 **NEW**	$115
CPU	AMD Ryzen 5 3600	$172
GPU	ASRock Challenger D RX 5600 XT 6GB	$270
RAM	16GB (2 x 8GB) XPG Gammix D30 @ 3,000MT/s **NEW**	$57
SSD	120GB Teamgroup GX1 2.5" SATA III **NEW**	$24
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$15
Approximate Price:		**$803**

INTEL INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$70
PSU	450W EVGA 450 BR **NEW**	$50
Mobo	ASRock Z390 Phantom Gaming 4 **NEW**	$140
CPU	Intel Core i5-9600K	$190
GPU	EVGA GeForce GTX 1660 Super Black Gaming 6GB	$215
RAM	16GB (2 x 8GB) G.Skill Ripjaws V Series @ 2,400MT/s	$60
SSD	120GB Teamgroup GX1 2.5" SATA III **NEW**	$24
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$15
Approximate Price:		**$794**

MID-RANGE

AGAIN, WE HAVE SMALL SAVINGS ON BOTH mid-range systems this month. An excellent deal on the Corsair Vengeance LPX DDR4-3200 has given the memory in the AMD build a minor speed bump (of 200MT/s, with no change in CAS latency) and knocking a few bucks off the price too. Meanwhile, the Intel system has adopted the same memory as its budget counterpart: Performance is basically unchanged, but we've saved a few bucks. Since memory speed has little to no impact on Intel CPU performance, there's no need to splash out—capacity and latency are all that matter.

A price hike on the Corsair CX650 made us opt for two new 650W power supplies. The AMD system gets EVGA's semi-modular 650 BQ, while the Intel machine gets the MasterWatt 650 from Cooler Master, equipped with a low-noise Silencio fan. Speaking of fans, we saved a bit more cash by swapping to the Noctua NH-U12S CPU cooler for our AMD build. This is a slight downgrade—the NH-U12S only has one fan as opposed to the previous Corsair A500's two—but Noctua's coolers are always a good choice.

The Ryzen 7 3700X isn't going anywhere, but the Intel Core i7-9700 is actually now cheaper than the i7-9700F. It's a strange turn of events, since the chips are near-identical, save for the 9700F's lack of integrated graphics. The i7-9700 is joined by a new motherboard too, the MSI MPG Z390 Gaming Edge AC, saving us another $20. The AMD build also scored a new mobo: The Asus TUF Gaming X570-Plus, which is excellent value at $165.

We shopped around for different Radeon GPUs, but the MSI RX 5700 dropped by 10 bucks, securing its place as the best-value 5700 available right now. Our previous RTX 2060 rose by the same amount, so we've shifted over to Gigabyte's factory-overclocked model to keep our price level. Elsewhere, small savings made us stick with the parts we had already. Both SSDs dropped by five bucks, and Fractal Design's Meshify C case remains a great choice.

AMD INGREDIENTS

PART			PRICE
Case	Fractal Design Meshify C		$85
PSU	650W EVGA 650 BQ	NEW	$80
Mobo	Asus TUF Gaming X570-Plus	NEW	$165
CPU	Ryzen 7 3700X		$280
Cooler	Noctua NH-U12S	NEW	$65
GPU	MSI Radeon RX 5700 8GB		$330
RAM	16GB (2 x 8GB) Corsair Vengeance LPX @ 3,200MT/s	NEW	$67
SSD	500GB Corsair Force MP600		$110
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD		$30
OS	Windows 10 Home 64-bit OEM		$100
Approximate Price:			**$1,312**

INTEL INGREDIENTS

PART			PRICE
Case	Fractal Design Meshify C		$85
PSU	50W Cooler Master MasterWatt	NEW	$90
Mobo	MSI MPG Z390 Gaming Edge AC	NEW	$190
CPU	Intel Core i7-9700	NEW	$320
Cooler	Phanteks PH-TC12DX		$58
GPU	Gigabyte GeForce RTX 2060 OC 6GB	NEW	$320
RAM	16GB (2 x 8GB) G.Skill Ripjaws V Series @ 2,400MT/s	NEW	$60
SSD	500GB Western Digital WD Black SN750 M.2 PCIe SSD		$70
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD		$30
OS	Windows 10 Home 64-bit OEM		$100
Approximate Price:			**$1,323**

BEFORE WE GET INTO THE NITTY-GRITTY of this: At the time of writing, *Death Stranding* on PC is free with both of the EVGA 2080 Supers we're using in these two builds (the KO Gaming in the AMD build, and the Black Gaming in the Intel build). Snap that up! Anyway... high-end power supplies seem to be stabilizing somewhat in the price department, so we'd recommend grabbing a Corsair RM850x at just $165 before the price rises again. You can see the same PSU in both turbo builds this issue.

In the AMD machine, we've upgraded our motherboard to the excellent MSI MEG X570 Unify. Some dedicated readers among you may remember this as one of the first X570 mobos we got our hands on, and it's still a great choice for any 3rd-gen Ryzen build. We've also swapped out our memory, sticking with G.Skill's TridentZ range but now opting for the newer, flashier TridentZ Neo. As we mentioned earlier, we're using EVGA's RTX 2080 Super KO Gaming in this machine now. Lastly, the 1TB model of the Corsair Force MP600 SSD is no longer the most affordable option for a 1TB PCIe 4.0 drive; Patriot has come in strong with the Viper Gaming VP4100, providing up to 5GB/s transfer speeds for just shy of $200.

The Intel system is getting a far more concrete improvement this month: A shiny new CPU, with the Intel Core i9-10900K. This is selling fast, but hopefully will be restocked by the time you read this. With 20 threads across 10 cores clocked up to 5.3GHz, this should show a solid performance boost when combined with the new Asus ROG Strix Z490-E Gaming motherboard. Fortunately, the LGA-1200 socket is compatible with LGA115X coolers meaning we have plenty of choice for coolers. That said we've gone for Fractal Design's Celsius+ S28 Dynamic X2 AIO cooler, which sports an omni-compatible CPU bracket. Finally, a tasty $60 discount on the Samsung 970 Evo Plus made a very persuasive argument for changing up our SSD. This drive effectively offers the fastest SSD storage available on Intel platforms, at least until Intel introduces PCIe 4.0 compatibility with its future processors.

AMD INGREDIENTS

PART		PRICE
Case	NZXT H710i	$170
PSU	850W Corsair RM850x NEW	$165
Mobo	MSI MEG X570 Unify NEW	$300
CPU	AMD Ryzen 9 3950X	$700
Cooler	Corsair iCUE H115i RGB Pro XT 280mm	$140
GPU	EVGA GeForce RTX 2080 Super KO Gaming 8GB NEW	$730
RAM	32GB (2 x 16GB) G.Skill TridentZ Neo @ 3600MT/s NEW	$179
SSD	1TB Patriot Viper Gaming VP4100 M.2 PCIe SSD NEW	$199
HDD	6TB Seagate BarraCuda ST6000DM003 HDD	$130
OS	Windows 10 Homes 64-bit OEM	$100
Approximate Price:		**$2,813**

INTEL INGREDIENTS

PART		PRICE
Case	NZXT H710i	$170
PSU	850W Corsair RM850x NEW	$165
Mobo	Asus ROG Strix Z490-E Gaming NEW	$300
CPU	Intel Core i9-10900K NEW	$550
Cooler	Fractal Design Celsius+ S28 Dynamic X2 PWM Black 280mm NEW	$151
GPU	EVGA GeForce RTX 2080 Super Black Gaming 8GB	$730
RAM	32GB (2 x 16GB) Corsair Vengeance RGB Pro @ 2,666MT/s	$148
SSD	1TB Seagate BarraCuda 510 M.2 PCIe SSD NEW	$190
HDD	6TB Seagate BarraCuda ST6000DM003 HDD	$130
OS	Windows 10 Homes 64-bit OEM	$100
Approximate Price:		**$2,634**

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